MDS™ Orbit MCR-4G

Managed Connected Router 4G and WiFi

Technical Manual

MDS 05-6628A01, Rev. A
June 2013
Preliminary

Digital Energy
MDS

Quick-Start instructions for this product are contained in publication 05-6702A01.

Visit our website for downloadable copies of all documentation at **www.gemds.com**.

TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 About This Manual 1
Software Command Notations 1
Authorized Features Icon 2

2.0 PRODUCT DESCRIPTION 3

2.1 Key Features 3
2.2 Interface Types 3
2.3 Typical Application 3
2.4 Connectors and Indicators 4
Grounding Considerations 9
Mounting Options 9
Optional DIN Rail Mounting 9
Antenna Planning & Installation 10
Accessories and Spares 12

3.0 Device Management 13

3.1 Connecting a PC 13
Differences Between Serial & SSH 13
Establishing Communication—Serial Interface 13
Setting Basic Parameters—First Steps 14
One-Time “Recovery” Passwords 14
3.2 Pre-Configured Settings 16
3.3 YANG Interface 16
CLI Login Prompt 17
3.4 Operational Topic Areas 23
Serial Console 24
Network 25
LAN 26
VLAN Operation 28
Cell 29
WiFi 32
Bridging 37
Routing 40
Firewall and NAT 41
VPN 50
DNS 57
DHCP Service 58
Iperf Service 61
Date, time and NTP 62
Geographical-location 63
User Management and Access Controls 64
Login-Lockout 66
RADIUS 67

File Servers 68
Certificate Management 69
Event Logging 77
Firmware Management 78
Support Bundle 80

4.0 Technical Reference 81

4.1 Troubleshooting 81
LED Status Indicators 81
4.2 Specifications 82
4.3 Agency/Regulatory Approvals 82
4.4 Glossary of Terms & Abbreviations 82

5.0 APPENDIX A – Data Configuration Tree 85

6.0 APPENDIX B – Command Line Interface (CLI) Features 101

7.0 APPENDIX C – Integrity Measurement Authority (IMA) 115

8.0 APPENDIX G – Licenses 125

Copyright and Trademark

This manual and all software described herein is protected by Copyright: 2013 GE MDS, LLC. All rights reserved. GE MDS, LLC reserves its right to correct any errors and omissions in this publication.

RF Safety Notice (English and French)

RF Exposure

Concentrated energy from a directional antenna may pose a health hazard to humans. Do not allow people to come closer to the antenna than the distances listed in the table below when the transmitter is operating. More information on RF exposure can be found online at the following website: **www.fcc.gov/oet/info/documents/bulletins**.

l'exposition aux RF

Concentré d'énergie à partir d'une antenne directionnelle peut poser un risque pour la santé humaine. Ne pas permettre aux gens de se rapprocher de l'antenne que les distances indiquées dans le tableau ci-dessous lorsque l'émetteur est en marche. Plus d'informations sur l'exposition aux RF peut être trouvé en ligne à l'adresse suivante: www.fcc.gov / oet / info / documents et bulletins.

Antennas must not be co-located. All transmission antennas must be at least 20 cm apart to comply with FCC co-location rules.

Orbit Device vs. Minimum RF Safety Distance

Radio Module Type	Minimum Safety Distance from Antenna
MCR-4G	20 cm
MCR-900	23 cm
Other models	Consult factory prior to operation.

FCC Part 15 Notice

Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Any unauthorized modification or changes to this device without the express approval of the manufacturer may void the user's authority to operate this device. Furthermore, this device is intended to be used only when installed in accordance with the instructions outlined in this manual. Failure to comply with these instructions may void the user's authority to operate this device.

Industry Canada Notice

This Class A digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.

Operational Safety Notices

The MDS Orbit MCR-4G may not be used in an environment where radio frequency equipment is prohibited or restricted in its use. This typically includes aircrafts, airports, hospitals, and other sensitive electronic areas.

Do not operate RF devices in an environment that may be susceptible to radio interference resulting in danger, specifically:

- **Areas where prohibited by law**

Follow any special rules and regulations and obey all signs and notices. Do not use the MCR-4G when you suspect that it may cause interference or danger.

- **Near Medical and life support equipment**

Do not use the MCR-4G in any area where medical equipment, or life support equipment may be located, or near any equipment that may be susceptible to any form of radio interference.

Cellular Operational Bands

The following table shows the bands in which the cellular module operates for each wireless technology.

System	Band	Band Name	Uplink (MHz)	Downlink (MHz)
CDMA	BC0	Cellular	824 – 849	869 - 894
	BC1	pcs	1850 – 1910	1930 - 1990
GPRS/EDGE	850	Cellular	824 – 849	869 – 894
	900	900	880.0 – 914.8	925.0 – 959.8
	1800	DCS	1710.2 – 1784.8	1805.2 – 1879.8
	1900	PCS	1850 – 1910	1930 – 1990
HSPA+	V	Cellular	824 – 849	869 – 894
	VIII	900	880 – 915	925 – 960
	II	PCS	1850 – 1910	1930 – 1990
	I	IMT	1920 – 1980	2110 – 2170
LTE	XIII	Verizon 700	777 – 787	746 – 756
GPS	L1	GPS	NA	1565.19 – 1585.65
	L1	Glonass		1598.06 – 1605.94

FCC IDs of Installed Transmitters

As of the date of printing, the following FCC identifiers are assigned to the modules listed below. For the latest, official listings of all agency approval information, please contact your factory representative.

CELL Modem FCC ID: PKRNVWE362, IC ID: 3229B:E362

WIFI Module FCC ID: M4Y-ZCN722MV1, IC ID 3195A-ZCN722MV1

CE Mark and RTTE Notice

This product, using the "WIFI internal radio module" only, is CE marked and compliant with the RTTE directive. Other configurations will be added for EU use in future releases.

Servicing Precautions

When servicing energized equipment, be sure to wear appropriate Personal Protective Equipment (PPE). During internal service, situations could arise where objects accidentally contact or short circuit components and the appropriate PPE would alleviate or decrease the severity of potential injury. When servicing radios, all workplace regulations and other applicable standards for live electrical work should be followed to ensure personal safety.

Manual Revision and Accuracy

This manual was prepared to cover a specific version of firmware code. Accordingly, some screens and features may differ from the actual unit you are working with. While every reasonable effort has been made to ensure the accuracy of this publication, product improvements may also result in minor differences between the manual and the product shipped to you. If you have additional questions or need an exact specification for a product, please contact GE MDS using the information at the back of this guide. In addition, manual updates can be found on our web site at www.gemds.com

Environmental Information

The manufacture of this equipment has required the extraction and use of natural resources. Improper disposal may contaminate the environment and present a health risk due to hazardous substances contained within. To avoid dissemination of these substances into our environment, and to limit the demand on natural resources, we encourage you to use the appropriate recycling systems for disposal. These systems will reuse or recycle most of the materials found in this equipment in a sound way. Please contact GE MDS or your supplier for more information on the proper disposal of this equipment.

Battery Disposal—This product may contain a battery. Batteries must be disposed of properly, and may not be disposed of as unsorted municipal waste in the European Union. See the product documentation for specific battery information. Batteries are marked with a symbol, which may include lettering to indicate cadmium (Cd), lead (Pb), or mercury (Hg). For proper recycling return the battery to your supplier or to a designated collection point. For more information see: www.weeerohsinfo.com.

Product Test Data Sheets

Test Data Sheets showing the original factory test results for this unit are available upon request from the GE MDS Quality Leader. Contact the factory using the information at the back of this manual. Serial numbers must be provided for each product where a Test Data Sheet is required.

CSA/us Notice

This product is approved for use in Class 1, Division 2, Groups A, B, C & D Hazardous Locations. Such locations are defined in Article 500 of the National Fire Protection Association (NFPA) publication NFPA 70, otherwise known as the National Electrical Code. The transceiver has been recognized for use in these hazardous locations by the Canadian Standards Association (CSA) which also issues the US mark of approval (CSA/US). The CSA Certification is in accordance with CSA STD C22.2 No. 213-M1987.

CSA Conditions of Approval: The transceiver is not acceptable as a stand-alone unit for use in the hazardous locations described above. It must either be mounted within another piece of equipment which is certified for hazardous locations, or installed within guidelines, or conditions of approval, as set forth by the approving agencies. These conditions of approval are as follows: The transceiver must be mounted within a separate enclosure which is suitable for the intended application.The antenna feedline, DC power cable and interface cable must be routed through conduit in accordance with the National Electrical Code. Installation, operation and maintenance of the transceiver

should be in accordance with the transceiver's installation manual, and the National Electrical Code. **Tampering or replacement with non-factory components may adversely affect the safe use of the transceiver in hazardous locations, and may void the approval.** A power connector with screw-type retaining screws as supplied by GE MDS must be used.

WARNING

EXPLOSION HAZARD!

Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous. Refer to Articles 500 through 502 of the National Electrical Code (NFPA 70) for further information on hazardous locations and approved Division 2 wiring methods.

1.0 INTRODUCTION

This manual describes the MDS Orbit MCR-4G (Managed Connected Router) shown in Figure 1. The unit is a highly secure, industrial grade, wireless communication product for broad based applications including control center monitoring, well site pad operations, and video surveillance. It serves the need for localized WiFi communications with a cellular back-up or backhaul option, while providing the extended temperature range and industrial-grade packaging inherent to GE MDS products. These features allow the best use of communication options at each installation site.

Figure 1. MCR-4G Unit
(Standard 2E1S configuration shown)

With a common hardware architecture and user interface, the MCR offers flexibility in network design and application, with simplified training, maintenance, and deployment costs. GE MDS provides an array of communication products with multiple interface options and a variety of enclosures to give customers the choice and flexibility to design their communications network to meet geographic and industry specific challenges. Information on other GE MDS products can be found by visiting our website at www.gemds.com.

1.1 About This Manual

This manual is intended for systems engineers, network administrators, and others responsible for planning, commissioning, using, and troubleshooting the wireless system. Installation steps are *not* included in this publication. For installation instructions, refer to the *MCR-4G Setup Guide*, part no. 05-6702A01. Electronic copies of all user documentation are available free of charge at **www.gemds.com**.

The MCR-4G Setup Guide, Part no. 05-6702A01, contains installation instructions, as well as basic startup information for this product.

All GE MDS user manuals and updates are available online at www.gemds.com.

1.1.1 Software Command Notations

The product is designed for software control via a connected PC. As such, there are no external controls or adjustments present. To show the names of software commands, keyboard entries, or other information displayed on a PC screen, a bolded font is used throughout the manual. In the case of tabular data displayed on a PC screen, a variation on this font is used to maintain proper layout. (See examples that follow.)

Bolded font example (used for software commands and keyboard entries)

`Bolded font example (used for tabular screen data)`

In the Device Management section, there are a number of command strings where information is presented by the unit, and a reply is required from the user. In such cases, information from the unit is shown in a non-bolded font, and the user response is shown in bold. For example:

(none) login: **admin**

Further, in some cases, command lines will be shown with non-bolded, *italicized* text contained within the string. Such text indicates the need for user-supplied parameters, such as the name of an item. For example:

set interfaces interface *myBridge* **virtual-type bridge**

In the above example, you would enter the specific name of your bridge to complete the command line entry.

NOTE: The software commands and responses shown in this manual were obtained from a unit operating in a lab environment. The information displayed may differ from field service conditions.

1.1.2 Authorized Features Icon

Some product features are dependent on purchased options and applicable regulatory constraints. A “key” icon appears near the heading of any such features.

2.0 PRODUCT DESCRIPTION

The MCR-4G is a rugged networking router providing comprehensive solutions for IP/Ethernet, serial, and machine-to-machine wireless communication. This industrial package provides integrated 4G LTE wireless technology and connectivity for Ethernet and serial devices requiring secure operation.

2.1 Key Features

MCR units include the following key features:

- **Security**—The unit uses industry-leading security features to protect data while maintaining compatibility with deployed infrastructures. Features include AAA user access with passwords and lockout protection, VPNs, encrypted storage, signed firmware, secure booting, integrity management, and more.
- **Small Form Factor**—The unit is housed in a rugged enclosure suited for operation in harsh industrial environments. It requires only protection from direct exposure to the weather, and may be easily mounted inside a NEMA enclosure for outdoor applications when required.
- **Network Interfaces**—Several network interfaces are present to provide connectivity for a variety of equipment and applications. Ethernet, serial, and WiFi interfaces provide local connections while a cellular interface provides access to public carrier networks.
- **User interface**—Multiple user interfaces are provided for configuration and monitoring of the unit. These include local serial console, web, SSH, USB, and NETCONF.

NOTE: When the unit is installed in hazardous locations, use only the serial or Ethernet connections on the unit's front panel. Do *not* use the USB port in hazardous locations.

- **NETCONF**—A next-generation management protocol is used that provides an array of features for device configuration and monitoring.
- **Network Management System**—The PulseNET Network Management System allows administering and monitoring the operation of small-to-large scale deployments.

2.2 Interface Types

MCR units are offered in two external interface offerings; 2 Ethernet/1 Serial (2E1S), or 2 Serial/1 Ethernet (2S1E). The 2E1S configuration (Figure 1) is the standard model and is the focus of this manual. Most information applies equally to both configurations, however.

2.3 Typical Application

The unit provides flexibility in network communications and may be used in a wide variety of applications. In a common scenario, it provides cellular connectivity to locally-connected devices that are located on a local/internal/private LAN or WiFi network. The unit acts as an Access Point on the WiFi interface to provide connectivity to WiFi clients. Figure 2 shows an example network in which the unit provides connectivity to multiple end devices. The end devices are connected via Ethernet, serial, and WiFi links.

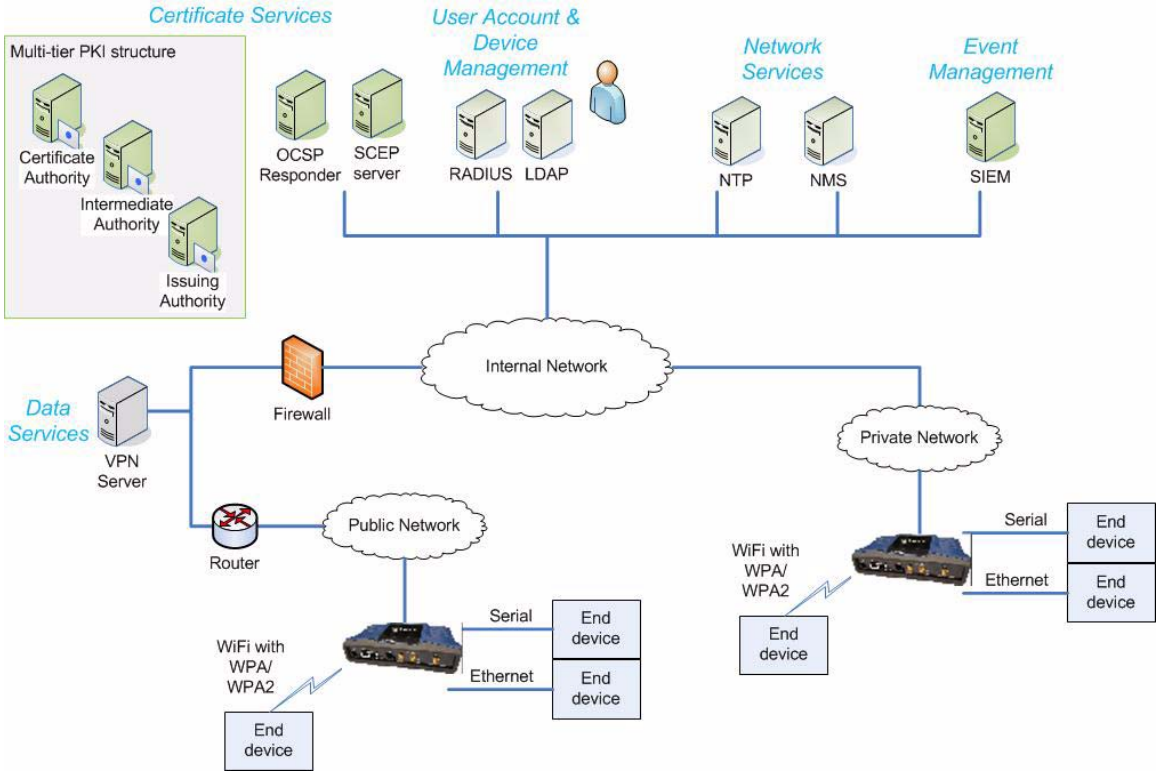


Figure 2. Typical MCR Application

2.4 Connectors and Indicators

Figure 3 shows the unit's front panel connectors and indicators. These items are referenced in the text that follows. The unit's LED Indicator Panel is described in Table 4 on Page 8.

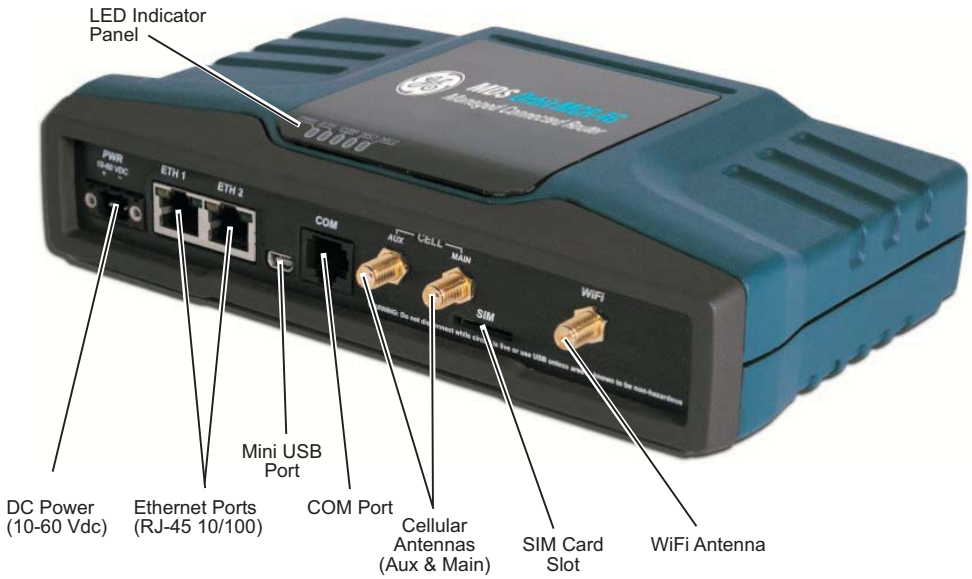


Figure 3. Connectors and Indicators
(2E1S configuration shown)

PWR—Two-conductor DC input connection. Input voltage must be well filtered, and within the range of 10-60 Vdc. The power supply must be capable of providing a maximum of 15 watts. The unit includes a 6-foot (1.83 meter) power cable suitable for indoor or outdoor use when properly connected. The DC power connector (Figure 4) is keyed, and can only be inserted one way.

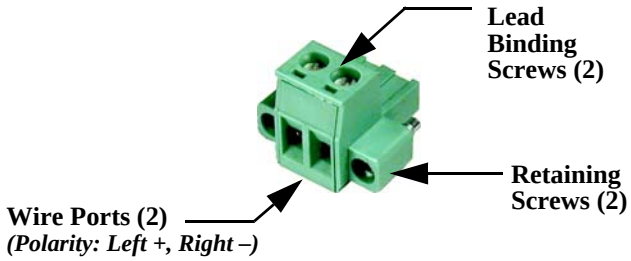
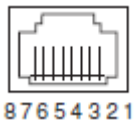


Figure 4. DC Power Connector (P/N 73-1194A39)

NOTE: The unit is designed for use in negative ground systems only.

ETH1 / ETH2— Ethernet connection port. These ports support both device management and payload data transport. Depending on product version, the unit may have one or two Ethernet ports. This is a standard RJ-45 jack, and features MDIX auto-sensing capability, allowing straight-through or crossover cables to be used.

Connecting to the unit via SSH supports device management and provides the same user interface available using the unit's COM1 serial port. Various options are available for passing Ethernet data, allowing system administrators to optimize the configuration for maximum efficiency, based on the system's operating characteristics.



(As viewed from the outside of the unit)

Table 1. ETH1/2 Pin Details

Pin	Function
1	Transmit Data (TX) High
2	Transmit Data (TX) Low
3	Receive Data (RX) High
4	Unused
5	Unused
6	Receive Data (RX) Low
7	Unused
8	Unused

USB Port—This port allows for connection of a laptop or PC. The port provides a local console for management of the device. A standard host-to-mini device USB 2.0 cable may be used.

COM Port—This connector serves as the serial interface port for both console management and payload data. It allows for connection of data equipment in the common Serial signaling standard. By default, the port is enabled for local console control. The COM port serves as the primary interface for connecting the unit to an external DTE serial device supporting the RS-232 or RS-485 serial data format. If necessary, an adapter may be used to convert the unit's RJ-45 serial jack to a DB-9F type (GE MDS part no. 73-2434A12).

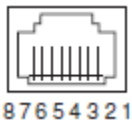
NOTE: Not all PCs include a serial port. If one is not available, the unit's USB port may be used to access the device management interface. Alternatively, a PC's USB port may be used with a USB-to-Serial adapter and appropriate driver software. These devices are available from several manufacturers.

The COM port supports a serial data rate of 1200-115200 bps (115200 default, asynchronous only). The unit is hardwired as a DCE device. Supported data formats for the COM port are:

8N1 - 8 char bits, no parity, 1 stop bit *(Default setting)*
8N2 - 8 char bits, no parity, 2 stop bits
8O1 - 8 char bits, odd parity, 1 stop bit
8O2 - 8 char bits, odd parity, 2 stop bits
8E1 - 8 char bits, even parity, 1 stop bit
8E2 - 8 char bits, even parity, 2 stop bits
7N1 - 7 char bits, no parity, 1 stop bit
7N2 - 7 char bits, no parity, 2 stop bits
7O1 - 7 char bits, odd parity, 1 stop bit
7O2 - 7 char bits, odd parity, 2 stop bits
7E1 - 7 char bits, even parity, 1 stop bit
7E2 - 7 char bits, even parity, 2 stop bits.

The tables below provide pin descriptions for the COM1 data port in RS-232 mode and RS-485 modes, respectively.

NOTE: The COM2 port, if present, is restricted to RS-232 mode; it cannot be used for RS-485.



(As viewed from the outside of the unit)

Table 2. COM1/2 Port Pin Details (RS-232)

Pin Number	Input/Output	Pin Description
1	Reserved	
2	OUT	DCD (Data Carrier Detect)
3	Reserved	
4	Ground	Connects to ground (negative supply potential) on chassis
5	OUT	RXD (Received Data)—Supplies received data to the connected device
6	IN	TXD (Transmitted Data)—Accepts TX data from the connected device
7	OUT	CTS (Clear to Send)
8	IN	RTS (Ready to Send)

Table 3. COM1 Port Pin Details (RS-485)

Pin Number	Input/Output	Pin Description
1	Reserved	
2	OUT	DCD (Data Carrier Detect)
3	Reserved	
4	Ground	Connects to ground (negative supply potential) on chassis
5	OUT	TXD+ (Transmitted Data +)—Non-inverting driver output. Supplies received payload data to the connected device.
6	IN	RXD+ (Received Data +)— Non-inverting receiver input. Accepts payload data from the connected device.
7	OUT	TX-/TXB (Transmitted Data -)—Inverting driver output
8	IN	RX-/RXB (Received Data -)— Inverting receiver input

COM1 Port notes and wiring arrangements (RS-485):

The COM1 port supports 4-wire and 2-wire RS-485 mode.

- RXD+ / RXB and RXD– / RXA are data sent *into* the unit
- RXD+ / RXB is positive with respect to RXD– / RXA when the line input is a “0”
- TXD+ / TXB and TXD– / TXA are data sent *out* by the unit
- TXD+ / TXB is positive with respect to the TXD– / TXA when the line output is a “0”

Cell Antennas (AUX and MAIN)—These SMA coaxial connectors are for attachment of cellular antennas. The MAIN connection is for basic cellular transmission/reception, and the AUX connector is for attachment of a receive-only antenna which provides for MIMO receive operation (diversity) with standard for 4G modules, improving signal quality in many installations. In general, both antennas should always be used for cellular operation. The GE MDS part number for this antenna type is 97-2485A04.

Figure 5. Directly-Connected Cellular Antenna (Typical)
(GE MDS Part No. 97-2485A04)

WiFi Antenna—Antenna connection for 2400 MHz WiFi service. The connector appears similar to the cellular connectors discussed above, but is a *Reverse-SMA* type. It contains a pin that matches with an SMA-F connector. The GE MDS part number for this antenna is 97-4278A48.

SIM Port—This port accepts a mini SIM card (2FF type) for 4G cell operation. The unit's cellular interface will not function without a valid SIM card installed. The customer is responsible for obtaining a provisioned SIM card for the appropriate service plan from their cellular provider.

CAUTION: *Do not* insert the SIM card when the unit is powered on.

Card Insertion: The SIM card only inserts one way; do not force it. It should be oriented with the printed label facing up, and the cut-off corner on the left side. This side is inserted first. A small instrument, such as a flathead screwdriver, may be helpful to *gently* push the SIM all the way in until it locks.

Information on determining the cell module's IMSI/IMEI (typically required for provisioning) is provided on Page 31 of this manual.

LED Status Indicators—The LEDs on the unit provide visual indications of the status of the device as follows:

Figure 6. LED Status Indicators

Table 4. Description of LED Status Indicators

LED Name	LED State	Description
PWR (DC Power)	Off	No power to unit
	Solid Green	Unit is powered, no problems detected
	Solid Amber	Initializing-bootup
	Fast Blink/Red (1x/sec.)	Alarm indication
ETH (Ethernet)	Off	No Ethernet link to network
	Solid Green	Ethernet link present
	Blinking Green	Ethernet traffic in/out
COM (Serial Comm. Port)	Off	No serial connection, or idle
	Blinking Green	Serial traffic in/out
NIC1 (Cell)	Off	No cellular connection
	Solid Green	Cell Connection w/RSSI >-80 dBm
	Solid Amber	Cell Connection w/RSSI between -90 & -80 dBm
	Solid Red	Cell connection w/RSSI<-90 dBm
NIC2 (WiFi)	Off	Interface disabled
Access Point Mode	Solid Green	Operating as AP and at least one client connection
	Solid Red	Operating as an AP and no client connection
Station Mode	Off	No connection
	Solid Green	Connected with "good" signal (RSSI stronger than -48 dBm)
	Solid Amber	Connected with "medium" signal (RSSI between -49 & -69 dBm)
	Solid Red	Connected with "weak" signal (RSSI less than -70 dBm)

NOTE: In addition to the LEDs above, the Ethernet connector has two embedded LEDs. A yellow indicates a link at 100 Mbps operation. A flashing green indicates Ethernet data traffic.

2.4.1 Grounding Considerations

To minimize the chance of damage to the unit and any connected equipment, a safety ground (NEC Class 2 compliant) is recommended which bonds the chassis, antenna system(s), power supply, and connected data equipment to a *single-point* ground, keeping all ground leads as short as possible.

Normally, the unit is adequately grounded if mounted with the flat brackets to a well-grounded metal surface. If the unit is not mounted to a grounded surface, it is recommended that a safety ground wire be attached to the threaded ground hole provided at the bottom of the enclosure. Alternatively, a safety ground wire may be attached to one of the mounting brackets.

The use of a lightning protector is recommended where the antenna cable enters the building; Bond the protector to the tower ground, if possible. All grounds and cabling must comply with applicable codes and regulations. One source for lightning protection products may be found online at http://www.protectiongroup.com/PolyPhaser.

2.4.2 Mounting Options

The unit may be mounted with flat mounting brackets or an optional 35 mm DIN rail attachment. Figure 7 shows the mounting dimensions for a unit equipped with flat mounting brackets.

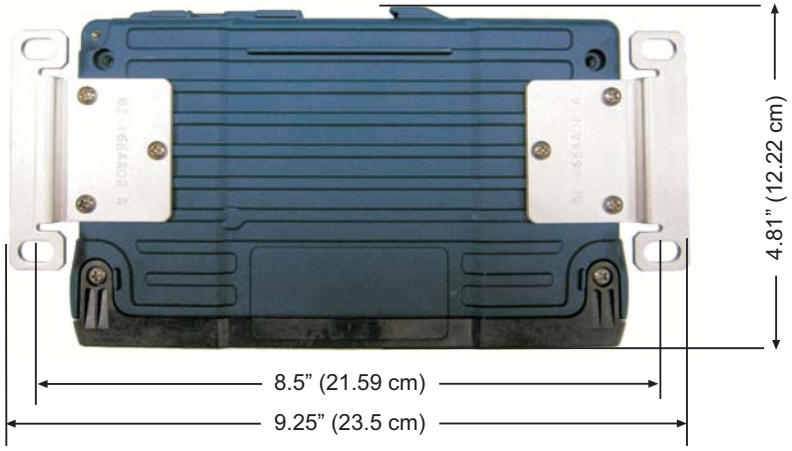


Figure 7. Flat Mounting Bracket Dimensions

NOTE: To prevent moisture from entering the unit, do not mount the case with the cable connectors pointing up. Also, dress all cables to prevent moisture from running along the cables and into the unit.

2.4.3 Optional DIN Rail Mounting

If ordered with the DIN rail mounting option, the unit is supplied with a DIN rail clip attached to the case. The integrated bracket on the unit's case allows for quick installation and removal from a DIN mounting rail as shown in Figure 8.

Figure 8. Attachment (Left) and Removal of unit from DIN Rail
(Unit shown is for bracket example only, and is not an MCR Unit.)

2.4.4 Antenna Planning & Installation

Consideration must be taken to select appropriate antennas for optimal RF performance. This section reviews the key factors involved in selecting and installing antennas for the MCR-4G. Only approved antennas may be used on the unit's RF output connectors, as listed in Table 5. The use of non-approved antennas may result in a violation of FCC rules, and subject the user to FCC enforcement action.

Table 5. Approved Antenna Types

Antenna Application	GE MDS Part Number
WiFi (direct connect), RP SMA 2.4-2.5GHz ANTENNA, 3.2dBi GAIN	97-4278A34
WiFi (external mount) Omni Ant N M Term 2400-2500, 2 dBi	97-4278A48
Cell (direct connect) 960/2170/2700MHz	97-2485A04
Cell (external mount, ground plane) 960/2170/2700MHz, NEEDS GND	97-2485A05
WiFi (Magnetic Mount) 5ft Cable RP SMA Plug	97-4278A78

Antenna Type and Orientation

It is important to use antennas designed to operate in the applicable cellular coverage bands with a Return Loss of 10 dB or better. Placement of the antennas also plays a key role in the coverage of the system. While the antennas can be placed directly on the face of the unit in some short range installations, the best performance is obtained when mounting antennas remotely using low loss coaxial cable. Antennas mounted in close proximity to each other can couple signals between them and desensitize the RF module.

When placing the indoor SMA style “paddle” antennas on the face of the unit, position them with a 90 degree angle of separation to improve the isolation. A “V” or an “L” configuration is a common approach to use *with the Main channel typically mounted for vertical polarization*. The multipath nature of Cellular systems means that polarization for indoor use is not normally a critical factor. Isolation between the antennas is more important.

Note that with any installation, there needs to be a minimum 20 cm spacing between the Wi-Fi antenna and any other radio antenna to avoid co-location difficulties.

Indoor use cases:

1. Direct mounting of LTE paddle antennas (GE MDS PN: 97-2485A04) on the Main and Aux Cell channels.

Cabled mounting of the Wi-Fi antenna (GE MDS PN: 97-4278A34) using a magnetic mount (GE MDS PN: 97-4278A78).

This configuration offers easy mobility for evaluation purposes or indoor applications with good cellular coverage (see Figure 9).

Figure 9. Direct Mounting of Cell Antenna; Cabled WiFi Antenna
Minimum 8-inch (20.32 cm) Separation Between Cell and WiFi

2. Cabled mounting of LTE paddle antennas (GE MDS PN: 97-2485A04) on the Main and AUX Cell channels.

Cabled mounting of the Wi-Fi antenna (GE MDS PN: 97-4278A34) using a magnetic mount (GE MDS PN: 97-4278A78) or direct mounting of the Wi-Fi to the unit.

This configuration works well for indoor applications in equipment closets for more permanent use.

Outdoor use case:

External enclosures—If the system is going to be installed in a weather-tight enclosure and mounted outside in the elements, cabled use of external LTE antennas (GE MDS PN: 97-2485A05) on the Main and AUX Cell channels with cabled use of the External Wi-Fi antenna (GE MDS PN: 97-4278A48) is a good solution. This configuration requires a suitable metallic ground plane for the Cellular antennas (8" diameter disc minimum for the 97-2485A05 series) or a suitable counterpoise for frequencies as low as 698 MHz. Metal enclosures work well for ground plane requirements when ground contact inside the box is not impeded by painted surfaces.

Do not use internally mounted antennas inside of metal enclosures.

Other antenna configurations can be easily customized for applications not listed here. Consult your factory representative for installation matters.

2.4.5 Accessories and Spares

Table 6 lists common accessories and spare items for use with the MCR-4G. GE MDS also offers an *Accessories Selection Guide* listing an array of additional items that may be used with the product. Contact your factory representative or visit **www.gemds.com** to obtain a copy of the guide.

Table 6. Accessories & Ancillary Items

Item	Description	Part Number
DC Power Plug, 2-pin, polarized	Mates with power connector on the unit's case. Screw terminals are provided for wires, threaded locking screws to prevent accidental disconnect.	73-1194A53
Setup Guide (for installation instructions)	Describes the installation and setup of the unit. It is a companion to this Technical Manual.	05-6702A01
Flat Mounting Bracket Kit	Brackets that attach to the bottom of the unit. Used for mounting to a flat mounting surface.	03-4123A14
COM Port Adapter	Converts the unit's RJ-45 serial jack to a DB-9F type.	73-2434A12

3.0 DEVICE MANAGEMENT

The MCR-4G offers several interfaces to allow device configuration and monitoring of status and performance. These include local serial console, USB, NETCONF, HTTPS, and Secure Shell (SSH) for local and remote access via the WAN and LAN networks. The serial console and SSH services offer a command line interface (CLI). There are three user accounts/roles for management access: **admin**, **tech**, and **oper**. User accounts can be centrally managed with a RADIUS server. RADIUS accounts can be mapped to one of the three user accounts/roles.

This section describes the steps for connecting a PC, logging in, and setting unit parameters. The focus is on the local serial console interface, but other methods are similar. The key differences are with initial access and appearance of data.

3.1 Connecting a PC

3.1.1 Differences Between Serial & SSH

Serial and SSH both present identical management capabilities, but the method of access is different for each. Serial involves an RS-232 serial connection from a PC to the unit's management COM port. SSH uses an Ethernet PC connection to the radio's ETH port. Maximum recommended cable length for a serial connection is 50 feet (15 meters). SSH can be connected to the radio from any network point that has connectivity with the PC, including remotely over the Internet, or using other networks.

The focus of these instructions is on *Serial* access, but SSH may also be used by following these additional points, which replace Steps 1-3 below:

- Connect to the unit with a PC that is on the same IP network as the MCR. Launch an SSH client/server program, and connect to the unit using its programmed IP address.
- The default IP address for the unit is 192.168.1.1. If you do not know the current IP address of the unit, follow the serial configuration instructions below, where you can determine the address and continue configuration.

3.1.2 Establishing Communication—Serial Interface

Follow these steps to configure the unit for its first use with serial console interface:

1. Connect a PC to the unit's COM port as shown in Figure 10. (Maximum recommended cable length: 50 ft./15 m)

NOTE: Not all PCs include a serial port. If one is not available, a USB port may be used, along with a USB-to-Serial adapter (with appropriate driver software). Adapters are available from many manufacturers, including GE MDS.

NOTE: If the COM port has been configured for terminal server operation, pressing +++ switches it to console (management) mode. Serial console mode is required for the following steps.

Launch a terminal communications program, such as HyperTerminal with the following communication parameters: **115200 bps (default speed), 8 bits, no parity, one stop bit (8N1), and flow control disabled**. Incorrect parameter settings are a frequent cause of connection difficulties; Double check to be sure they are correct.

If necessary, an adapter may be used to convert the unit's RJ-45 serial jack to a DB-9F type (GE MDS part no. 73-2434A12). If no serial port exist on the PC, a USB-to-serial adapter cable may also be used to connect to the MCR unit.

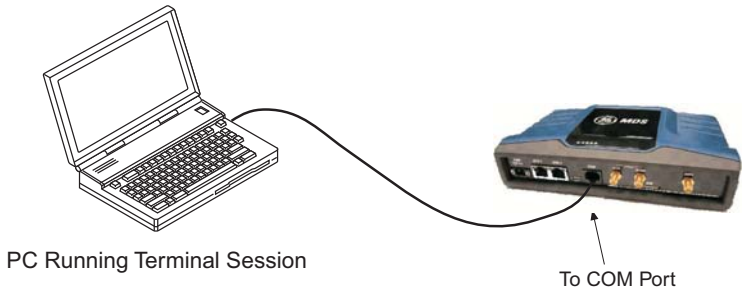


Figure 10. PC Connection for Programming/Management

2. Press the ENTER key at half-second intervals to receive the **Login:** prompt. This indicates that the unit is ready to receive commands.

3. At the **Login:** prompt, enter **admin** (lower case) and press ENTER.

4. If no password has been previously set, enter the default password (**admin**) and press ENTER; Otherwise, enter the saved password at the **Password:** prompt. (Before placing the unit in final service, it is recommended that the default password be changed to ensure that only authorized users have access.)

5. After successful login, the command prompt appears where you may configure and manage a number of unit settings.

3.1.3 Setting Basic Parameters—First Steps

There are three tasks that should be performed after initial startup and connection to a PC, as follows:

1. Create One-Time Programmable passwords for device recovery in the event a password is lost.

2. Change the login passwords.

3. Evaluate the default factory configuration and lock it down to user's required security level.

Tab Completion Feature

Tab-completion is a powerful feature that presents CLI users with assistance while typing. Depending on the text that was already entered, tab-completion will display different possible completions. When the tab key is pressed and no text has been entered, the CLI shows all possible commands that can be typed.

3.1.4 One-Time "Recovery" Passwords

The MDS Orbit platform employs extensive security measures to prevent unauthorized access. As such, there are no hidden manufacturer passwords or other "backdoors" found in less secure products. If a password is lost, there is no way to access the unit, except by using a one-time password (OTP) for recovery. This must be established by the user beforehand. Without a one-time password, the unit will not be accessible, and the hardware will need to be replaced. *Not even the factory will be able to assist you if a password is lost, so creating a one-time password is strongly encouraged.*

One-Time Passwords: How They Work

One-time recovery passwords put control directly and exclusively in the user's hands. They are similar to spare keys for a lock. If you make a spare key, and put it away safely, you can take it out to quickly gain entry when your primary key is lost. If you don't make a spare, you are always at risk of locking yourself out.

A one-time recovery password is different from the one used to log into the unit on a routine basis. It is *only* for use when the primary password is lost or forgotten. When a one-time password is used to log in, that password is *automatically revoked* from the list of passwords created. (You may create up to five one-time passwords at one time, and more can be created if some get used). A password cannot be used again for log-in to the unit (hence the name one-time-password).

Creating a One-Time Password

To create a one-time recovery password, proceed as follows:

1. Upon successful log-in, enter the following command:

   request system recovery one-time-passwords create function <selected function>

   A one-time password is automatically generated and displayed on the screen. Copy this password and save it in the desired location on your PC. **There is no way to ever view it again from the command line console, so be sure it is properly saved.**

2. To create additional one-time passwords (up to a total of five), repeat the step above.

Logging in With a One-Time Password

To use the one-time password for log-in, proceed as follows:

1. At the username prompt, enter the word **recovery**.

2. At the **password** prompt, paste in the one-time-password saved earlier on your PC. Using a one-time-password forces the unit to perform the "function" which was previously defined when the password was created:
   - **factory-reset**—The unit resets its entire configuration to factory defaults
   - **login**—The unit allows logging in with "admin" privileges

Special case: If someone has disabled console access on the COM port, the login prompt will still be present on that console, but only one-time-passwords will be accepted. This is done to provide a way to recover the unit in the case where the COM port has been disabled and the unit cannot be accessed via TCP.

Deleting a One-Time Password

As noted earlier, a one-time password is automatically revoked when it is used for log-in. A revoked password may be replaced, but it must first be removed from the list so a new one can be generated. Any of the five stored passwords may be removed on demand. As long as there is a free slot, an additional password can be created, up to the maximum number of five. Logs are generated when the user creates, deletes or logs in with a one-time-password. To remove an existing password from the list, proceed as follows:

Enter the command **request system recovery one-time-passwords delete identifier X**, where X is a number 1 through 5.

The current list of passwords may be viewed by issuing the command **show system recovery one-time-passwords**. The following is an example output from that command. On the unit shown, only two passwords have been stored. Password 1 or 2 can be deleted from this list.

```
                                                        DATE
IDENTIFIER  FUNCTION  STATUS   DATE CREATED              REVOKED  USER
-----------------------------------------------------------------------
1           login     useable  2012-06-19T00:27:24+00:00
2           login     useable  2012-06-19T00:27:25+00:00
```

3.2 Pre-Configured Settings

The MCR is highly configurable to meet field requirements, but comes pre-configured as follows:

- The COM and USB ports are enabled for local console operation
- The Ethernet ports are bridged with the WiFi AP
- WiFi AP SSID is set based on the unit's serial number, and takes the form of: **GEMDS_SERNUM>** (the serial number is printed on the chassis sticker)
- WiFi is enabled with passphrase: **GEMDS_ORBIT**
- A DHCP server is enabled for WiFi clients and the Ethernet LAN ports
- Cellular service is enabled with firewall/router rules in place.

The commands below show how this is accomplished. Each command string begins with the word **set**:

1. **set interfaces interface Wi-Fi wifi-config mode access-point**
2. **set interfaces interface Wi-Fi wifi-config mode access-point ap-config ap GEMDS_<SERNUM> broad-cast-ssid true privacy-mode wpa2-personal psk-config psk GEMDS_ORBIT**
3. **set interfaces interface Cell ipv4 dhcp**
4. **set interfaces interface Cell filter input IN_UNTRUSTED**
5. **set interfaces interface Cell filter output OUT_UNTRUSTED**
6. **set interfaces interface Cell nat source MASQ**
7. **set services serial console serial-ports [COM1 USB1]**
8. **set interfaces interface Bridge virtual-type bridge**
9. **set interfaces interface Bridge ipv4 address 192.168.1.1 prefix-length 24**
10. **set interfaces interface Bridge bridge-settings members port LAN1**
11. **set interfaces interface Bridge bridge-settings members port LAN2**
12. **set interfaces interface Bridge bridge-settings members wifi-ap GEMDS_<SERNUM>**
13. **set services dhcp v4subnet 192.168.1.0/24 range-start 192.168.1.2 range-end 192.168.1.10 broad cast-address 192.168.1.255 router 192.168.1.1**

3.3 YANG Interface

The unit employs a data modeling language called YANG to model the configuration and status of the device. YANG is used in conjunction with the NETCONF protocol to provide a device-specific data model that can be administered by any NETCONF-capable NMS. The YANG data model is released with each version of the device so NMS administrators can accurately administer the device per release.

Together, YANG and NETCONF present a structured user interface for the unit. The device data defined by the YANG data model is either Operational Data or Configuration Data. Configuration Data may be changed, but Operational Data can only be viewed.

Configuration Data

Configuration Data is any piece of data that can be changed by an administrator and the changes are persistent even if the device reboots. The IP address of the LAN port is an example of Configuration Data.

Operational Data

Operational Data is any piece of data that is volatile and will not be saved if the device is rebooted. Operational data is typically *read-only*, such as statistics information showing status or a value representing the operation of the device. Ethernet statistics are an example of operational data.

Default Values

While configuring the unit, some of the configuration data may not need to be explicitly set, but instead the data assumes the default value defined in the data model. For example, when a File Server configuration is added and the server type is specified as TFTP, then the remote TFTP port will default to **69** if the user does not explicitly specify the port. Data nodes that do not have a default value will require the user to input a value for that node during configuration. The command line interface (CLI) prompts the user to enter a value for a node if the node is mandatory and does not have a default value.

When the user views the configuration, the nodes that have default values and have not been explicitly set by the user are not displayed. Users can selectively view these defaulted values by using **details** option on the CLI. The **show** command can be used to view configuration data. Notice the information displayed is different, depending on which mode the CLI is in; *Operational* or *Configuartion*.

Remote Procedure Call (Request)

This is an action that a user requests the device to perform. Rebooting the device, for example, is an action that is modeled as a request.

Privilege

A user who logs on to the device will belong to a role-based group. Each group is limited in capability to view operational data or to change configuration data. Less-privileged groups will not be presented with the option of viewing or changing data on the CLI which can be done by higher-privileged groups.

Changing Configuration Data and committing changes

Changing configuration data requires two steps. The first step is to use a user-interface to add, remove, or alter a piece of configuration data. The second step is to use the user-interface to *commit* the change. Multiple changes can be made prior to committing them. This two-step process allows users to make multiple changes to the configuration and apply them in a bulk commit. Additionally, the device can validate the bulk commit and reject it if there is an error.

3.3.1 CLI Login Prompt

The CLI is available via the serial console or an SSH session. Use the default serial console settings shown in the SERIAL CONSOLE section to connect a Computer to the unit via a serial cable. Once the network settings are configured, users can also connect to the device via SSH over the network.

The CLI prompts for a login to the device before any other actions can be made. The default username is **admin** and the default password is **admin**. These credentials should be changed prior to placing the unit in full service.

(none) login: **admin**

Password: **(valid password)**

Welcome to the CLI

admin connected from 127.0.0.1 using console on (none)

admin@(none) 04:24:12>

Using the CLI

This section will describe how to use the CLI by using an example: changing the name of the unit.

Step 1: Login to the device using the serial console and use the default username "**admin**" and the default password **admin.**

(none) login: **admin**

Password:

Welcome to the CLI

admin connected from 127.0.0.1 using console on (none)

admin@(none) 04:24:12>

Step 2: Instruct the device to enter configuration mode by typing "**configure**" and pressing the enter key:

admin@(none) 04:51:06> **configure**
Entering configuration mode private
[ok][2012-06-20 04:51:07]
[edit]
admin@(none) 04:51:07%

Step 3: Change the device name by typing in the following, followed by enter**: set system name Device539**

admin@(none) 05:31:14% **set system name Device539**
[ok][2012-06-20 05:32:45]
[edit]
admin@(none) 05:32:45%

Step 4: Verify the change looks correct by reading the data back using the following, followed by the enter key: **show system name**

admin@(none) 05:32:53% **show system name**
name Device539
[ok][2012-06-20 05:35:28]
[edit]
admin@(none) 05:35:28%

Step 5: Commit the change by typing in the following, followed by the enter key: **commit**

admin@(none) 05:36:20% **commit**
Commit complete.
[ok][2012-06-20 05:36:21]
[edit]
admin@(none) 05:36:21%

Step 6: Exit the configuration mode by typing the following, followed by the enter key: **exit**

admin@(none) 05:40:15% **exit**
[ok][2012-06-20 05:40:17]
admin@(none) 05:40:17>

Step 7: Exit the login session by typing the following, followed by the enter key: **exit**

admin@(none) 05:40:32> **exit**
(none) login:

CLI Quick Reference Table

Table 7 provides a summary listing of commonly-needed tasks and the appropriate commands to enter. The table can be used as a quick reference before consulting the more detailed information which follows in this section. Each CLI command is proceeded by the symbol **>** for operational command, or **%** for a configuration command.

Table 7. CLI Quick Reference Table

If you wish to...	***Enter this CLI command:***
Create a one-time password	**>request system recovery one-time-password create function <userfunction>**
View all network interface status and statistics	**>show interfaces**
Create a bridge	**%set interfaces interface** *myBridge* **virtual-type bridge**
Add an interface to a bridge	**%set interfaces interface** *myBridge* **bridge-settings members port ETH1**
Remove an interface from a bridge	**%delete interfaces interface** *myBridge* **bridge-settings members port ETH1**
View WiFi settings	**>show configuration interfaces interface** *Wi-Fi* **wifi-config | details**
Set WiFi AP SSID	**%set interfaces interface** *Wi-Fi* **wifi-config mode access-point ap-config ap** *myssid*
Enable WiFi WPA2-Personal security	**%set interfaces interface** *Wi-Fi* **wifi-config mode access-point ap-config ap** *myssid* **privacy-mode** *wpa2-personal* **psk-config psk** *mypassphrase*
Configure WiFi details	**%set interfaces interface** *Wi-Fi* **wifi-config ap-config ap *myssid* broadcast-ssid true**
Monitor WiFi statistics	**>show interfaces interface** *Wi-Fi* **statistics | repeat 5**
View the cell module status	**>show interfaces interface** *Cell*
View the cell APN	**>show configuration interfaces interface** *Cell* **cell-config apn**
View the routing table	**>show routing**
View the event log	**>show table logging event-log | nomore**
Set the admin user's password	**>request system authentication change-password user** *admin* **password** *admin*
Set the device name	**%set system name** *"Mydevice"*
Set the baud rate on COM1	**%set services serial ports** *COM1 baud-rateb19200*
Download a firmware package from TFTP server at 192.168.1.10	**>request system firmware reprogram-inactive-image filename** *iwc-bkrc-1_0_0.mpk* **manual-file-server {** *tftp* **{ address** *192.168.1.10* **} }**
Monitor firmware download status	**>show system firmware reprogramming-status**
Export configuration file to a server	**>request system configuration-files export filename** *myConfig.txt* **manual-file-server {***tftp {192.168.1.10* **} }**
Reboot device to firmware image #2	**>request system power restart-to-image location 2**

Specific examples

Example #1

In Figure 11, the MCR-4G is functioning as a WiFi Access Point to provide connectivity between a set of laptops and a handheld device. The MCR-4G is also acting as a DHCP server for the laptops and handheld device.

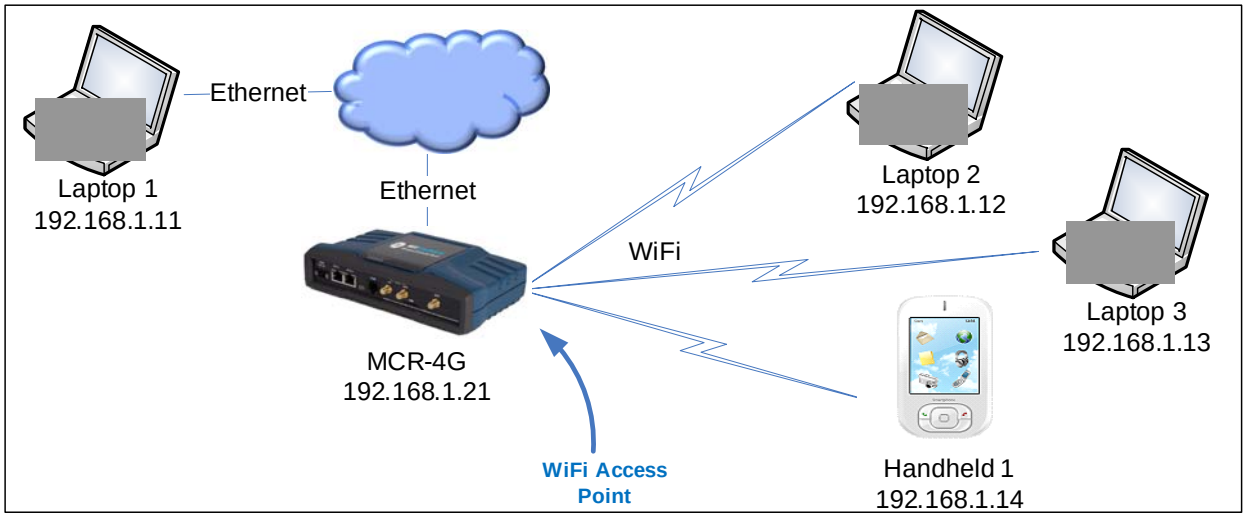


Figure 11. Example 1: Unit Providing Laptop and Handheld Device Connectivity

The following commands will configure the MCR-4G for this scenario.

1. **%set interfaces interface** *Wi-Fi physical-interface Wi-Fi* **wifi-config mode access-point ap-config ap** *myssid*
2. **%set interfaces interface** *myBridge* **virtual-type bridge**
3. **%set interfaces interface** *myBridge* **bridge-settings members port** *ETH1*
4. **%set interfaces interface** *myBridge* **bridge-settings members wifi-ap** *myssid*
5. **%set interfaces interface** *myBridge* **ipv4 address** *192.168.1.21* **prefix-length** *24*
6. **%set services dhcp enabled true v4subnet** *192.168.1.0/24* **domain-name gemds range-start** *192.168.1.10* **range-end** *192.168.1.19* **router** *192.168.1.1* **broadcast-address** *192.168.1.255*

Example #2

In Figure 12, there are two MCR-4G devices, one acting as a WiFi Access Point, the other as a WiFi Station. Together, the MCR-4G devices are providing a wireless bridge between the laptop and the SCADA device.

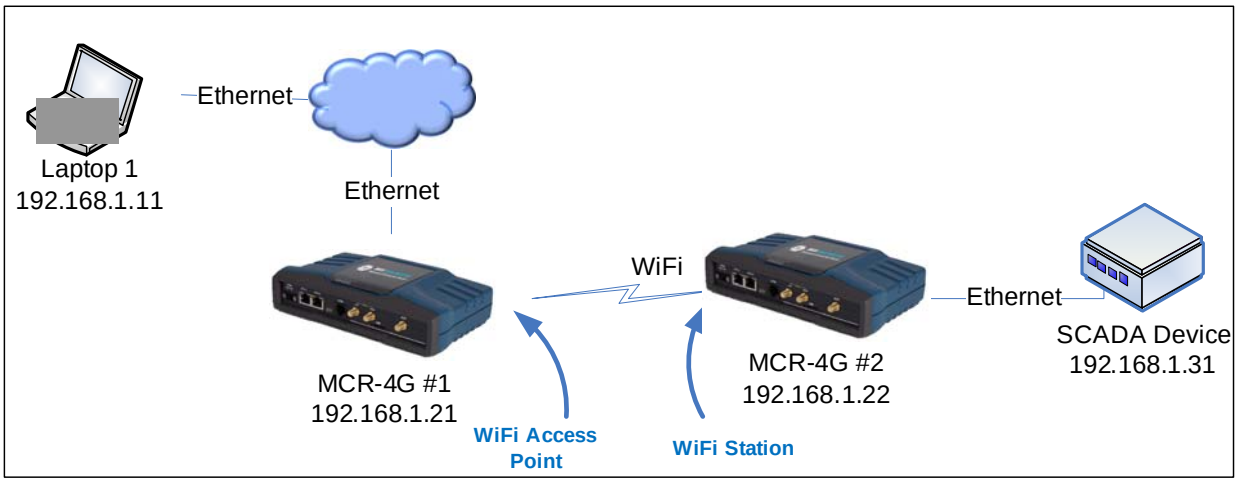


Figure 12. Example 2: Units Providing Wireless Bridge Between Laptop & SCADA Device

The following commands will configure the MCR-4G #1 for this scenario.

1. **%set interfaces interface** *Wi-Fi physical-interface Wi-Fi* **wifi-config mode access-point ap-config ap** *myssid*
2. **%set interfaces interface** *myBridge* **virtual-type bridge**
3. **%set interfaces interface** *myBridge* **bridge-settings members port** *ETH1*
4. **%set interfaces interface** *myBridge* **bridge-settings members wifi-ap** *myssid*
5. **%set interfaces interface** *myBridge* **ipv4 address** *192.168.1.21* **prefix-length** *24*
6. **%set services enabled true dhcp v4subnet** *192.168.1.0/24* **domain-name gemds range-start** *192.168.1.10* **range-end** *192.168.1.19* **router** *192.168.1.1* **broadcast-address** *192.168.1.255*

The following commands will configure the MCR-4G #2 for this scenario.

1. **%set interfaces interface** *Wi-Fi physical-interface Wi-Fi* **wifi-config mode station station-config ap** *myssid* **enabled** *true*
2. **%set interfaces interface** *myBridge* **virtual-type bridge**
3. **%set interfaces interface** *myBridge* **bridge-settings ports port** *ETH1*
4. **%set interfaces interface** *myBridge* **bridge-settings ports wifi-station interface Wi-Fi**
5. **%set interfaces interface** *myBridge* **ipv4 address** *192.168.1.22* **prefix-length** *24*

Example #3

Figure 13 shows the MCR-4G #2 device acts as a terminal server to provide connectivity to the serial-based SCADA device via UDP.

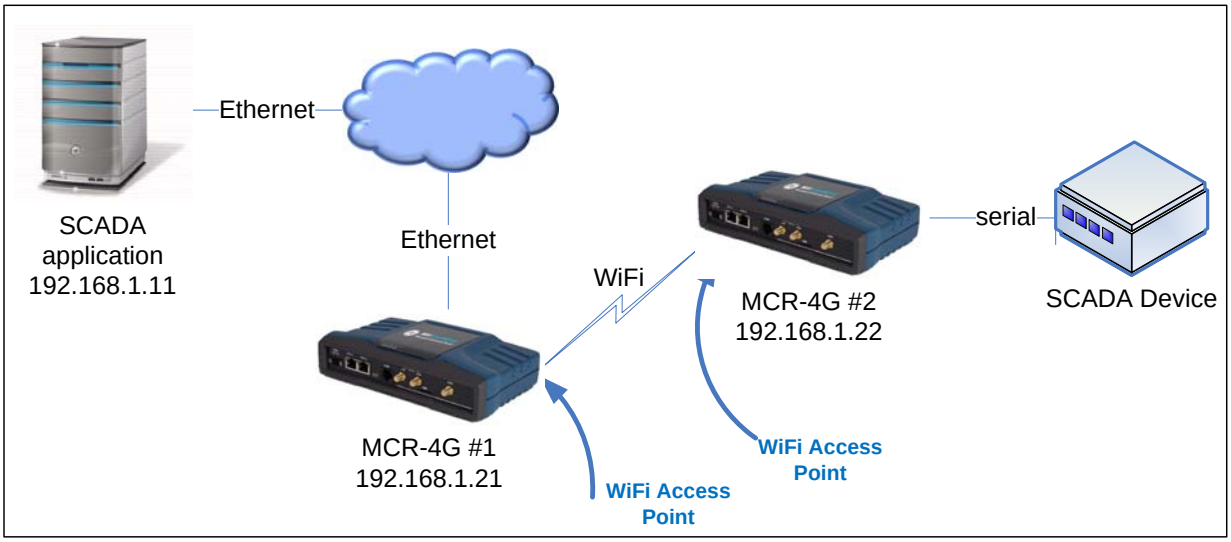


Figure 13. Example 3: Unit Providing Connectivity to Serial-Based SCADA Device via UDP

The following commands will configure the MCR-4G #2 for this scenario.

1. **%set interfaces interface** *Wi-Fi physical-interface Wi-Fi* **wifi-config mode station station-config ap** *myssid* **enabled** *true*
2. **%set interfaces interface** *myBridge* **virtual-type bridge**
3. **%set interfaces interface** *myBridge* **bridge-settings ports port** *ETH1*
4. **%set interfaces interface** *myBridge* **bridge-settings ports wifi-station interface Wi-Fi**
5. **%set interfaces interface** *myBridge* **ipv4 address** *192.168.1.22* **prefix-length** *24*
6. **%set services serial terminal-server server COM1 mode udp port** *30000* **remote address** *192.168.1.11* **port** *30001*

Example #4

In Figure 14, the MCR-4G provides internet access for a laptop that is accessing a public web page.

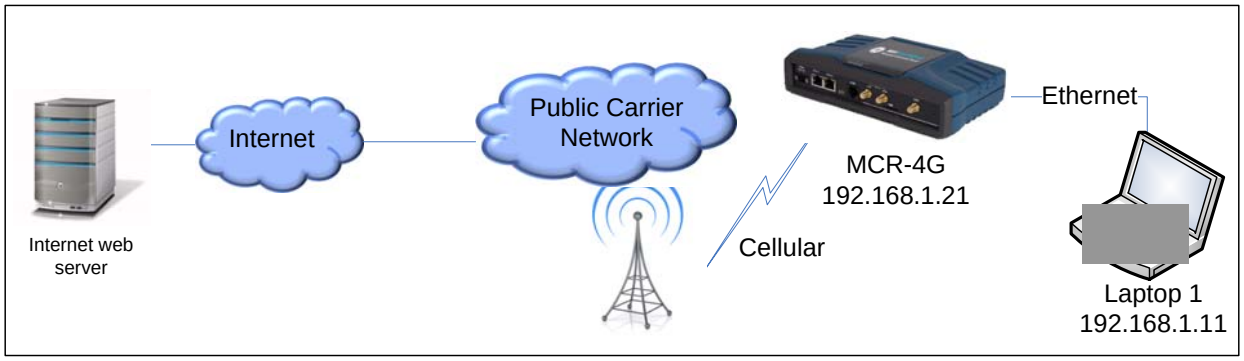


Figure 14. Example 4: Unit Providing Internet Access for Laptop

SIM Type: In this scenario, the MCR-4G has a SIM installed that simply provides Internet access.

The following commands will configure the MCR-4G for this scenario.

1. **%set interfaces interface** *myBridge* **virtual-type bridge**
2. **%set interfaces interface** *myBridge* **bridge-settings ports port** *ETH1*
3. **%set interfaces interface** *myBridge* **ipv4 address** *192.168.1.21* **prefix-length** *24*
4. **%set interfaces interface** *Cell physical-interface Cell* **enabled** *true*
5. **%set services firewall enabled** *true*
6. **%set services firewall filter** *IN_UNTRUSTED*
7. **%set services firewall filter** *IN_UNTRUSTED* **rule** *1* **match protocol** *icmp*
8. **%set services firewall filter** *IN_UNTRUSTED* **rule** *1* **actions action** *accept*
9. **%set services firewall filter** *IN_UNTRUSTED* **rule** *10* **match protocol** *all*
10. **%set services firewall filter** *IN_UNTRUSTED* **rule** *10* **actions action** *drop*
11. **%set interfaces interface** *Cell* **filter input** *IN_UNTRUSTED*
12. **%set services firewall filter** *OUT_UNTRUSTED* **rule** *10* **match protocol** *all*
13. **%vset services firewall filter** *OUT_UNTRUSTED* **rule** *10* **actions action** *accept*
14. **%set interfaces interface** *Cell* **filter output** *OUT_UNTRUSTED*
15. **%set services firewall nat source rule-set** *MASQ*
16. **%set services firewall nat source rule-set** *MASQ* **rule** *1* **source-nat interface**
17. **%set services interfaces interface** *Cell* **nat source** *MASQ*

3.4 Operational Topic Areas

The following headings describe key operational features of the MCR unit, and list configuration options for them.

Serial Console

A serial cable may be used to connected to a COM port on the unit to access the CLI. The default serial console settings are 115200 bps with 8N1 format. A mini-USB-to-USB cable may also be used to connect to a Computer in case no serial port exists. If a mini-USB connection is used, the computer must contain the appropriate device driver. A driver for serial operation can be found on GE MDS website.

Configuring

This sequence shows how to add console access to the COM serial port and set the baud rate to 19200 bps:

```
admin@(none) 00:04:43% set services serial console serial-ports [ COM1 COM2 ]
[ok][2012-06-19 00:04:57]

[edit]
admin@(none) 00:04:59% set services serial ports COM2 baud-rate b19200
[ok][2012-06-19 00:05:28]

[edit]
admin@(none) 00:05:28% commit
Commit complete.
[ok][2012-06-19 00:07:51]

[edit]
admin@(none) 00:07:51%
```

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state and statistics:

```
admin@(none) 00:10:38> show configuration services serial | details
ports COM1 {
  line-mode     rs232;
  duplex-mode   full;
  baud-rate     b115200;
  byte-format   bf8n1;
  hw-flow-control false;
  vmin          255;
  vtime         1;
  capability    3;
}
ports COM2 {
   line-mode      rs232;
   duplex-mode    full;
   baud-rate      b19200;
   byte-format    bf8n1;
   hw-flow-control false;
   vmin           255;
   vtime          1;
   capability     0;
}

console {
   serial-ports [ COM1 COM2 ];
}
[ok][2012-06-19 00:12:00]
admin@(none) 00:12:00>
```

Network

Understanding

The unit has multiple network interfaces including LAN, Cellular, and WiFi. Each of these has numerous networking features and each feature is described below in a separate section:

- Static or dynamic IP addressing (DHCP) for each interface
- Bridging
- Firewall
- Routing
- VPN

Configuring

See each individual section for details about configuring the LAN, Cell, WiFi interfaces, and related networking features.

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state and statistics of all the network interfaces:

```
admin@(none) 03:38:19> show interfaces
```

LAN

Understanding

The unit has external Local Area Network (LAN) ports that can be used to connect to a local LAN. It supports both IPv4 and IPv6 addresses and may be assigned multiple IP addresses. The LAN port can be assigned static IP addresses or a dynamically allocated address can be assigned using DHCP.

NOTE: The LAN port should be assigned IP addresses only if it is a routed interface (that is, *not* in a bridge). Refer to the section on Bridging later in the document.

Configuring

The following sequence shows how to configure the LAN1 port with a static IPv4 address:

```
admin@(none) 06:03:53> configure
Entering configuration mode private
[ok][2012-06-20 06:03:54]

admin@(none) 06:04:45% set interfaces interface ETH1 ipv4 address 192.168.1.11 prefix-length 24
[ok][2012-06-20 06:05:01]

[edit]
admin@(none) 06:05:01% commit
Commit complete.
[ok][2012-06-20 06:05:03]

[edit]
admin@(none) 06:05:03%
```

The following sequence shows how to configure the LAN1 port to obtain a dynamic IPv4 address using DHCP:

```
admin@(none) 06:03:53> configure
Entering configuration mode private
[ok][2012-06-20 06:03:54]

admin@(none) 06:04:45% set interfaces interface ETH1 ipv4 dhcp
[ok][2012-06-20 06:05:01]

[edit]
admin@(none) 06:05:01% commit
Commit complete.
[ok][2012-06-20 06:05:03]

[edit]
admin@(none) 06:05:03%
```

Monitoring

Ensure the CLI is in Operational mode. Follow the example below to view the state and statistics of the LAN port:

```
admin@(none) 03:38:19> show interfaces interface ETH1
interfaces interface ETH1
 if-index 2
```

```
status mac-address 00:00:00:00:01:01
status mtu  1500
status link up
status ipv4 address [ 192.168.1.10/24 192.168.1.11/24 ]
status ipv6 address [ fe80::200:ff:fe00:101/64 ]
status counters collisions 0
status counters multicast 0
status counters rx_bytes 2022760
status counters rx_compressed 0
status counters rx_crc_errors 0
status counters rx_dropped 0
status counters rx_errors 0
status counters rx_fifo_errors 0
status counters rx_frame_errors 0
status counters rx_length_errors 0
status counters rx_missed_errors 0
status counters rx_packets 8859
status counters rx_over_errors 0
status counters tx_aborted_errors 0
status counters tx_bytes 21371
status counters tx_carrier_errors 0
status counters tx_compressed 0
status counters tx_dropped 0
status counters tx_errors 0
status counters tx_fifo_errors 0
status counters tx_heartbeat_errors 0
status counters tx_packets 232
status counters tx_window_errors 0
[ok][2012-06-21 03:38:24]
admin@(none) 03:38:24>
```

VLAN Operation

Understanding

Virtual Local Area Networks (VLANs) are generic interface types in the MCR-4G, and can be assigned unique IP addresses. They are treated the same as any other interface type, but they offer a way to link traffic between interface ports. As such, a VLAN device can be thought of as a "bridging device."

Setup

To setup a VLAN, you must first create one or more VLAN interfaces. Two sample commands are shown below for doing this; one with an ID of **99** and another with an ID of **300**:

set interfaces interface mgmt_vlan virtual-type vlan vlan-config vlan-id 99

set interfaces interface video_vlan virtual-type vlan vlan-config vlan-id 300

Operational Modes

VLAN interfaces can have three separate modes: **none** (default), **trunk**, or **access**. These modes are used to set interface behavior, and examples of their use are provided below.

Trunk: To add ETH1 as a trunk (tagged) port in both defined VLANs above, the command is:

set interfaces interface ETH1 vlan-mode trunk vlans [video_vlan mgmt_vlan]

By issuing these commands, two bridges are created internally, which are background operations, hidden from the user. (In this case, the two bridges are **br_vlan99** and **br_vlan300**).

When an interface is specified as a trunk member of the VLAN, the system creates a Linux VLAN interface (**eth0.99 & eth0.300**) which strips off VLAN tags on ingress, and applies them on egress. This new device is then added as a member of the **br_vlan99 & br_vlan300** bridges.

Access: To set ETH2 as an access port for **video_vlan** the command is:

set interfaces interface ETH2 vlan-mode access vlan video_vlan

This command adds the ETH2 interface as a member of the **br_vlan300** bridge, although it is not outwardly apparent to the user.

Native VLANs

A VLAN device may also be specified as a "native" VLAN, and this is set by the command:

set interfaces interface my_native_vlan virtual-type vlan vlan-config vlan-id 600 native-vlan true

As in the earlier examples, native VLANs are nothing more than a bridge, but they cannot have trunk ports. It should also be understood that bridges cannot contain other bridges. For this reason, it is not possible to assign a bridge interface to a VLAN. Also, VLANs serve as interfaces, so you can assign IP addresses to them and treat them the same as any other interface type.

Cell

Understanding

The unit incorporates a 4G LTE module capable of operation on Verizon Wireless LTE/CDMA network (LTE 700Mhz Band 13) in the United States. The unit supports routing of TCP/UDP/IP data from the Cellular WAN network interface to any of the other network interfaces (including WiFi or LAN) using the IPsec VPN or network address and port translation (NAPT) feature and to the COM1 (or COM2) serial port using the terminal server service. The configuration of these uses cases is specified in respective sections on VPN, Firewall and NAT, and Terminal Service.

The cellular modem inside the unit supports main (primary) and secondary antenna (for receive diversity). The primary antenna must be installed for cell modem to register with the cellular network. It is strongly recommended that secondary antenna be installed for achieving a robust cellular link. There should be no physical obstructions around the antennas. The main and diversity antennas must have a minimum amount of 27 dB isolation from each other to ensure optimal LTE mode operation of the module.

Cell Configuration Hierarchy

```
interface cell {
        cell-config {
                apn <apn-name>
                lte-recovery <true|false>
                keep-alive {
                        address <host name or address>
                        interval <host name or address>
                }
        }
}
```

Access Point Name (APN)

After MCR has registered on the cellular network, it sets up the IP data connection with a specific Packet Data Network identified by the Access Point Name (APN). APN is a string identifier.

The MCR comes preconfigured with APN of “vzwinternet”. Hence, it attempts to set up a data connection toward internet PDN that provides internet connectivity. For this data connection to succeed, a SIM card that has been provisioned for internet access needs to be obtained from the service provider and installed in MCR.

If a private network (PN) account has been arranged with the service provider, a SIM card will be issued from that account. When the modem is powered up with such a SIM, the default APN on the modem is automatically updated by the service provider to the one that identifies the user’s private network. This procedure is called OTA APN update. This procedure may not always succeed, and hence, requires the user to manually update the APN on the MCR. The following example shows how to update APN manually via CLI:

```
admin@(none) 15:28:44> config
Entering configuration mode private
[ok][2013-01-18 15:28:46]

[edit]
admin@(none) 15:28:46% set interfaces interface cell cell-config apn GEDEROC.GW6.VZWENTP
[ok][2013-01-18 15:29:36]

[edit]
admin@(none) 15:29:36% commit
Commit complete.
[ok][2013-01-18 15:29:46]

[edit]
admin@(none) 15:29:46% exit
```

LTE Recovery

The cellular modem used inside the unit may occasionally remain in a 3G (EVDO-REV A) service state and not transition to 4G LTE. The firmware incorporates a recovery mechanism to recover from this condition. If the cellular modem has been in 3G coverage for more than 15 minutes, the firmware resets the modem to bring it back into LTE service state. LTE recovery is enabled by default. This mechanism should be disabled if the unit is deployed in areas that either lack or have poor LTE coverage. Otherwise, the cellular modem will unnecessarily reset every 15 minutes.

This feature allows the cellular modem to maintain a connection in situations where no traffic is passed over cellular link for long periods of time, which would otherwise cause disruption. The keep alive mechanism sends an ICMP echo message to the configured address/host at the configured interval. This feature should be used only if an application is passing data very infrequently over a cellular connection (*i.e.*, if data is passed at a rate of less than once per hour).

The commands for setting 3G/4G operation are as follows:

4G Operation – Default programming.

```
% set  interfaces interface Cell cell-config service-recovery lte-recovery true
% commit
```

3G Operation – Turn off the LTE Recovery Mode to allow continual 3G mode operation without periodic disconnection for 4G service search.

```
% set  interfaces interface Cell cell-config service-recovery lte-recovery false
% commitKeep Alive
```

NOTE: The Verizon network can disconnect the cellular connection if any packets get routed from LAN to Cellular interface without undergoing masquerading (Source Network Address Translation (NAT) before exiting the cellular interface. Therefore, always configure masquerading on the cellular interface. Refer to the "Firewall and NAT" section in this manual for more information on NAT configuration.

Monitoring

Ensure the CLI is in Operational mode. Follow the example below to view the cellular interface state and statistics:

```
admin@(none) 16:23:34> show interfaces interface cell
interfaces interface eth1
 if-index 6
 status mac-address 00:a0:c6:00:00:00
 status mtu  1500
 status link up
 status ipv4 address [ 172.18.175.131/29 ]
 status ipv6 address [ fe80::2a0:c6ff:fe00:0/64 ]
 status counters collisions 0
 status counters multicast 0
 status counters rx_bytes 50574
 status counters rx_compressed 0
 status counters rx_crc_errors 0
 status counters rx_dropped 0
 status counters rx_errors 0
 status counters rx_fifo_errors 0
 status counters rx_frame_errors 0
 status counters rx_length_errors 0
```

```
status counters rx_missed_errors 0
status counters rx_packets 259
status counters rx_over_errors 0
status counters tx_aborted_errors 0
status counters tx_bytes 40114
status counters tx_carrier_errors 0
status counters tx_compressed 0
status counters tx_dropped 0
status counters tx_errors 0
status counters tx_fifo_errors 0
status counters tx_heartbeat_errors 0
status counters tx_packets 273
status counters tx_window_errors 0
cell-status imsi 311480023788535
cell-status imei 990000624071751
cell-status iccid 89148000000234127059
cell-status mdn 5853534418
cell-status apn GEDEROC.GW6.VZWENTP
cell-status sw-version "1.41 SVN 0 [2011-08-23 18:47:59]"
cell-status sim-state "SIM INIT COMPLETED"
cell-status modem-state connected
cell-status roaming-state home
cell-status service-state lte
cell-status rssi -61
[ok][2013-01-18 16:23:38]
```

Determining the Cell Module's IMSI/IMEI

When provisioning the cell module for network service, the cellular provider typically requires the International Mobile Subscriber Identity code (IMSI) or International Mobile Station Equipment Identity code (IMEI) to be provided. These codes can be determined by entering the following command:

show interfaces interface *Cell* **cell-status**

(Where *Cell* is the configured name for the cellular device. **Cell** is the factory default name, but it may have been changed by a previous user.)

When the above command is entered, a number of items are returned as shown in the example below. The first two items (highlighted blue) show the IMSI and IMEI codes. These are unique for each unit.

```
cell-status imsi 311480023631413
cell-status imei 990000947608727
cell-status iccid 89148000000232694605
cell-status mdn  5857948168
cell-status apn  VZWINTERNET
cell-status app-sw-version 0.0.5
cell-status modem-sw-version "4.08.02 SVN 0 [2012-12-21 10:52:58]"
cell-status sim-state Ready
cell-status modem-state connected
cell-status roaming-state home
cell-status service-state lte
cell-status rssi -62
```

WiFi

Understanding

The internal WiFi module has FCC modular approval and may only be used with one of the GE MDS approved antennas (see 802.11 WiFi Module Specifications below). The WiFi antenna is connected to the reverse-SMA connector on the unit's front panel. *Only* these antennas may be used. The WiFi module can be configured to operate as an 802.11b/g/n Access Point or Station. The operational mode and frequency can be configured through the user interface.

The specifications for the 2.4 GHz WiFi module are as follows:

- Protocol: IEEE 802.11b/g/n OFDM 6 to 54Mbps, CCK 1 to 11Mbps
- Frequency Range: 2400 to 2500 MHz
- Maximum Transmit Power: 18 dBm (Default is 15 dBm)
- Permissible Antennas:
  - GE MDS 97-4278A36
  - GE MDS 97-4278A34
  - GE MDS 97-4278A35
- FCC: Part 15C
- FCC ID: VRA-SG9011028
- WiFi Antenna Connector: Female Reverse SMA

The unit supports the following WiFi security modes:

1. **None** (should be used only to test connectivity)

2. **WPA2 + CCMP/AES Encryption** – This mode should be used if all client devices support WPA2/CCMP.

3. **Encryption + TKIP Encryption** – This mode should be used if there is mix of both legacy client devices that only support WPA/TKIP and newer devices that support WPA2/CCMP.

Also, WPA and WPA2 can be configured further in following modes:

- **Personal** – This uses pre-shared keys (passphrases) configured on the MCR and client devices.
- **Enterprise** – This supports EAP-TLS based authentication of client devices (configured with certificates/keys) via RADIUS.

The default SSID is based on the unit's serial number, and takes the form of: **GEMDS_<SERNUM>** (the serial number is printed on the chassis sticker). The default password for WiFi operation is **GEMDS_ORBIT**.

AP Mode

Basic configuration with defaults

The following will configure a basic access point with 'somessid' and default settings.

```
admin@(none) 00:17:10% set interfaces interface physical-interface WiFi wlan0 wifi-config mode
access-point ap-config ssid somessid

[ok][2012-06-19 00:17:29]

[edit]
admin@(none) 00:17:29% show interfaces interface wlan0 wifi-config | details
mode     access-point;
```

```
tx-power 15;
ap-config {
   ssid          somessid;
   broadcast-ssid  true;
   channel       6;
   station-max    7;
   station-timeout 300;
   beacon-interval 100;
   operation-mode  80211g;
   dtim-period    2;
   rts-threshold   2347;
   fragm-threshold 2346;
   privacy-mode    none;
}
[ok][2012-06-19 00:17:37]
admin@(none) 00:17:37% commit
Commit complete.
```

Privacy mode configuration

The default privacy mode, as shown above, is ***none***.

The following configures the unit to use WPA2-Personal security with the default CCMP/AES encryption.

```
admin@(none) 00:19:02% set interfaces interface wlan0 wifi-config ap-config privacy-mode wpa2-per-
sonal psk-config psk somepassphrase

[ok][2012-06-19 00:26:51]

[edit]
admin@(none) 00:26:51% show interfaces interface wi-fi wifi-config | details
mode    access-point;
tx-power 15;
ap-config {
   ssid          somessid;
   broadcast-ssid  false;
   channel       6;
   station-max    7;
   station-timeout 300;
   beacon-interval 100;
   operation-mode  80211g;
   dtim-period    2;
   rts-threshold   2347;
   fragm-threshold 2346;
   privacy-mode    wpa2-personal;
   psk-config {
      encryption ccmp;
      key-mgmt   wpa-psk;
      psk       somepassphrase;
   }
}
[ok][2012-06-19 00:27:01]

[edit]
admin@(none) 00:27:01% commit
Commit complete.
```

The following configures the unit to use WPA2-Personal security with the CCMP/AES encryption + TKIP encryption.

```
admin@(none) 00:19:02% set interfaces interface wlan0 wifi-config ap-config privacy-mode wpa2-per-
sonal psk-config encryption ccmp-tkip psk somepassphrase

[ok][2012-06-19 00:26:51]

[edit]
admin@(none) 00:26:51% show interfaces interface wlan0 wifi-config | detail
mode     access-point;
tx-power 15;
ap-config {
   ssid           somessid;
   broadcast-ssid false;
   channel        6;
   station-max    7;
   station-timeout 300;
   beacon-interval 100;
   operation-mode 80211g;
   dtim-period    2;
   rts-threshold  2347;
   fragm-threshold 2346;
   privacy-mode   wpa2-personal;
   psk-config {
      encryption ccmp-tkip;
      key-mgmt   wpa-psk;
      psk        somepassphrase;
  }
}
[ok][2012-06-19 00:27:01]

[edit]
admin@(none) 00:27:01% commit
Commit complete.
```

Other configuration

The following configures the device to broadcast its ssid, support 802.11b/g/n modes, and operate on channel 3.

```
admin@(none) 00:27:59% set interfaces interface wlan0 wifi-config ap-config broadcast-ssid true
operation-mode 80211n channel 3

[ok][2012-06-19 00:36:30]

[edit]
admin@(none) 00:36:30% show interfaces interface wlan0 wifi-config | details
mode     access-point;
tx-power 15;
ap-config {
   ssid           somessid;
   broadcast-ssid true;
   channel        3;
   station-max    7;
   station-timeout 300;
   beacon-interval 100;
   operation-mode 80211n;
   dtim-period    2;
   rts-threshold  2347;
   fragm-threshold 2346;
   privacy-mode   wpa2-personal;
   psk-config {
      encryption ccmp;
      key-mgmt   wpa-psk;
      psk        somepassphrase;
```

```
  }
}
[ok][2012-06-19 00:36:39]

[edit]
admin@(none) 00:36:39% commit
Commit complete.
```

Station Mode

This command sets the unit to act as WiFi station to connect to an AP with **somessid** and WPA2 Personal security.

```
admin@(none) 00:43:09% set interfaces interface wlan0 wifi-config
station-config ap somessid enabled true privacy-mode wpa2-personal psk-config psk somepass-
phrase

[ok][2012-06-19 00:43:26]

[edit]
admin@(none) 00:43:26% show interfaces interface wlan0 wifi-config | detail
mode     station;
tx-power 15;
station-config {
   ap somessid {
      priority     1;
      enabled      true;
      privacy-mode wpa2-personal;
      psk-config {
         encryption ccmp;
         key-mgmt   wpa-psk;
         psk        somepassphrase;
      }
   }
}
[ok][2012-06-19 00:43:34]

[edit]
admin@(none) 00:43:34% commit
Commit complete.
```

Monitoring

Ensure the CLI is in Operational mode.

Access Point Mode

The following shows status with two stations connected. Note that in this case **bssinfo-x** represents the station statistics/data (*i.e.*, id is the station MAC address).

```
admin@(none) 01:06:26> show interfaces interface wlan0 wifi-status
wifi-status mode “Access Point”
wifi-status ssid “”
wifi-status privacy “”
wifi-status channel 0
wifi-status tx-power 15
wifi-status bssinfo-0 “id: 98:4b:4a:5a:53:2d, inactive: 330, rx bytes: 1126, rx packets: 11, tx bytes: 355,
tx packets: 3, tx retries: 0, tx failed: 0, tx bitrate: 6, signal: -37,   authorized : yes,   authenticated : yes”

wifi-status bssinfo-1 “id: f4:ec:38:99:01:e2, inactive: 7770, rx bytes: 529, rx packets: 6, tx bytes: 355, tx
packets: 3, tx retries: 0, tx failed: 0, tx bitrate: 6, signal: -47,   authorized : yes,   authenticated : yes”

[ok][2012-06-19 01:06:29]
```

Station Mode

The following shows status when connected to a configured AP. Note that in this case **bssinfo-0** represents the AP (*i.e.*, id is the bssid).

admin@(none) 00:52:24> show interfaces interface wlan0 wifi-status

wifi-status mode Station

wifi-status ssid somessid

wifi-status privacy “”

wifi-status channel 6

wifi-status tx-power 15

wifi-status bssinfo-0 “id: 4c:e6:76:50:85:32, inactive: 89750, rx bytes: 206463, rx packets: 1766, tx bytes: 1135, tx packets: 13, tx retries: 0, tx failed: 0, tx bitrate: 65, signal: -13, authorized : yes, authenticated : yes”

[ok][2012-06-19 00:52:34]

Bridging

Understanding

The unit supports transparent bridging of LAN and WiFi networks. The bridge forwards traffic between LAN and WiFi networks at the layer-2 of OSI model. This allows LAN and WiFi clients to be in the same IP sub-network.

The bridge learns the clients' locations by analyzing the source address of incoming frames from all attached networks (LAN and WiFi network). For example, if a bridge sees a frame arrive on LAN port from Host A, the bridge concludes that Host A can be reached through the segment connected to LAN port. Through this process, the bridge builds a forwarding table (the learning process). When a frame is received on one of the bridge's interfaces, the bridge looks up the frame's destination address in its forwarding table. If the table contains an association between the destination address and any of the bridge's ports aside from the one on which the frame was received, the frame is forwarded out the indicated port. If no association is found, the frame is flooded to all ports except the inbound port. Broadcasts and multicasts also are flooded in this way.

Typically, for LAN/WiFi-to-Cellular Router use case (a.k.a LAN/WiFi HotSpot), the LAN and WiFi interface (acting as an Access Point) are bridged. However, for security and bandwidth considerations, a user might want to remove LAN and WiFi networks from the bridge (*i.e.*, configuring LAN and WiFi networks as separate IP networks). In this network setup, broadcast/multicasts data packets coming into WiFi are not directed out the LAN connection and vice versa.

The bridged network is addressable via bridge interface (a virtual interface). The interfaces that are in the bridge are called bridged interfaces. The interfaces that are not in the bridge are called routed interfaces. Bridging is performed between bridged interfaces. Routing is performed between routed interfaces. The bridge interface is a routed interface.

NOTE: The Cellular modem by its nature can never be added to the bridge and is, therefore, a routed interface. Advanced details of networking concepts such as routing and bridging are outside the scope of this manual but are available through various training materials freely available on the Internet.

Theory of Operation

Refer to Figure 15 for this discussion. In a typical application, the MCR-4G provides cellular connectivity to locally connected devices that are located on the user's local/internal/private LAN or WiFi network. The MCR-4G acts as an Access Point on the Wi-Fi interface, providing connectivity to Wi-Fi clients. The Wi-Fi traffic is combined with the local Ethernet port traffic through a Layer 2 bridge. The serial interface is matched to a terminal server that encapsulates serial data over a TCP or UDP connection.

The MCR-4G provides Network Address Translation (NAT) (both Masquerading and Port Forwarding) as well as Firewalling between the cellular data interface (WAN side) and the local network (LAN/WiFi). The MCR-4G can also act as a VPN client to provide a secure tunnel for LAN data to the user's local network (LAN/WiFi). This configuration obviates the need for NAT, as the back-office network behind the VPN Concentrator (VPNC) can address the local LAN or WiFi network directly via the secure tunnel.

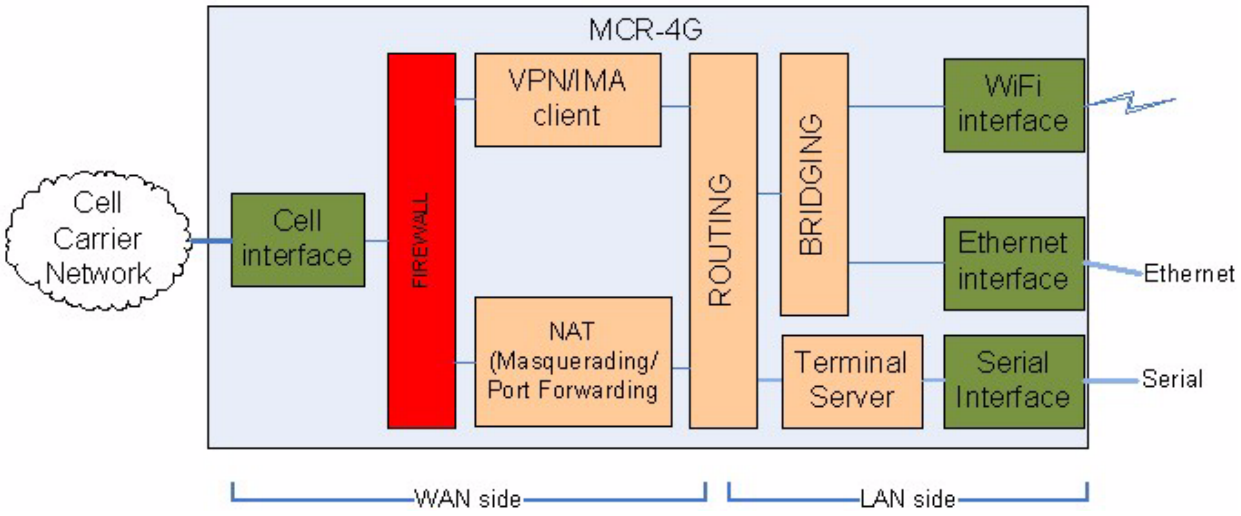


Figure 15. Bridging Functions Diagram

Configuring

Creating a bridge interface and assigning it an IP address:

admin@(none) 00:02:09% set interfaces interface *myBridge* **type bridge**

admin@(none) 00:02:20% set interfaces interface *myBridge* **bridge-settings ageing-time** ***500***

admin@(none) 00:22:26% set interfaces interface *myBridge* **ipv4 address 192.168.1.10 prefix-length 24**

Adding LAN interface to the bridge:

admin@(none) 00:06:20% set interfaces interface *myBridge* **bridge-settings members port eth0**

Adding WiFi interface to the bridge:

admin@(none) 00:06:20% set interfaces interface *myBridge* **bridge-settings members wifi-ap / wifi-stationwlan0**

Removing LAN interface from the bridge:

admin@(none) 00:06:36% delete interfaces interface *myBridge* **bridge-settings members port eth0**

Removing WiFi interface from the bridge:

admin@(none) 00:06:20% delete interfaces interface *myBridge* **bridge-settings members wifi-ap / wifi-station wlan0**

Removing the bridge interface:

admin@(none) 00:23:00% delete interfaces interface *myBridge*

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state and statistics of a bridge. In this example, bridge br0 is bridging LAN (eth0) and WiFi (wlan0) networks.

```
interfaces interface br0
 if-index 4
 status mac-address 00:19:70:94:7e:2d
 status mtu 1500
 status link up
 status ipv4 address [ 10.10.1.1/24 ]
 status ipv6 address [ fe80::c4ff:bdff:feaf:b9f6/64 ]
 status counters collisions 0
 status counters multicast 0
 status counters rx_bytes 7094971
 status counters rx_compressed 0
 status counters rx_crc_errors 0
 status counters rx_dropped 0
 status counters rx_errors 0
 status counters rx_fifo_errors 0
 status counters rx_frame_errors 0
 status counters rx_length_errors 0
 status counters rx_missed_errors 0
 status counters rx_packets 151306
 status counters rx_over_errors 0
 status counters tx_aborted_errors 0
 status counters tx_bytes 275063
 status counters tx_carrier_errors 0
 status counters tx_compressed 0
 status counters tx_dropped 0
 status counters tx_errors 0
 status counters tx_fifo_errors 0
 status counters tx_heartbeat_errors 0
 status counters tx_packets 3199
 status counters tx_window_errors 0
 bridgeStatus stp port eth0
  number          1
  priority        0
  state           forwarding
  path-cost       19
  designated-root   8000.001970947e2d
  designated-cost   0
  designated-bridge 8000.001970947e2d
  designated-port   32769
 bridgeStatus stp port wlan0
  number          2
  priority        0
  state           forwarding
  path-cost       100
  designated-root   8000.001970947e2d
  designated-cost   0
  designated-bridge 8000.001970947e2d
  designated-port   32770
[ok][2013-01-24 14:27:15]
```

Routing

Understanding

The unit can be configured to route IP packets between routed interfaces.

Configuring a default static route:

```
admin@(none) 00:50:52% set routing static-routes ipv4 route 1 dest-prefix 0.0.0.0/0 next-hop
192.168.1.10
```

Configuring a static host route:

```
set routing static-routes ipv4 route 2 dest-prefix 10.2.3.1/32 next-hop 192.168.1.9

admin@(none) 00:04:57% show routing static-routes
ipv4 {
   route 1 {
      dest-prefix 0.0.0.0/0;
      next-hop    192.168.1.10;
route 2 {
      dest-prefix 10.2.3.1/32;
      next-hop    192.168.1.9;
[ok][2012-06-19 00:05:01]

[edit]
admin@(none) 00:05:01%
```

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state of the routing table:

```
admin@(none) 00:05:27> show routing

OUTGOING    SOURCE          V6UR:DEST   V6UR:NEXT   V4UR:DEST      V4UR:NEXT
INTERFACE   PROTOCOL   AGE  PREFIX      HOP         PREFIX         HOP
-------------------------------------------------------------------------
eth0        static     -    -           -           0.0.0.0/0      192.168.1.10
eth0        static     -    -           -           10.2.3.1/32    192.168.1.9
eth0        direct     -    -           -           192.168.1.0/24   -

OUTGOING    SOURCE          V6UR:DEST   V6UR:NEXT   V4UR:DEST   V4UR:NEXT
INTERFACE   PROTOCOL   AGE  PREFIX      HOP         PREFIX      HOP
-------------------------------------------------------------------------
eth0        direct     -    fe80::/64   -           -           -
eth1        direct     -    fe80::/64   -           -           -

[ok][2012-06-19 00:05:29]
```

Firewall and NAT

Understanding

The MCR incorporates a firewall service that provides the following functionality:

1. Packet filtering to permit or deny incoming or outgoing traffic on an interface.

2. Network Address Translation (NAT)
   - Source NAT - Masquerading
   - Destination NAT – Port Forwarding

Packet Flow

This section provides a simplified view of packet flow for various categories of traffic flows going in and out of the MCR unit. Figure 16 shows the flow of packets terminating at MCR. For example, device management traffic using SSH or NETCONF protocol terminating at local device management process within the MCR unit.

Figure 16. Packets Terminating at MCR

Figure 17 shows flow of packets originating from the MCR unit. For example, DNS queries and/or VPN connection setup traffic originating from local VPN service within the MCR unit.

Figure 17. Packets Originating from MCR

Figure 18 shows the flow of packets being forwarded (routed) through the MCR unit. For example, IP packets arriving inside IPsec VPN tunnel, being routed from cellular WAN to the local Ethernet interface.

Figure 18. Packets Being Forwarded Through MCR

Figure 19 shows the flow of packets being port-forwarded (DNAT'ed) through the MCR unit. For example, TCP traffic arriving at the cellular interface and getting port forwarded to a private host connected to the local Ethernet interface.

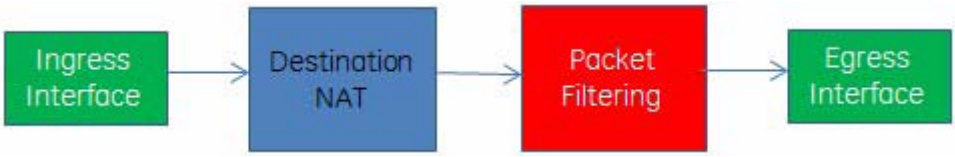


Figure 19. Packets Being Port-Forwarded Through MCR

Figure 20 shows the flow of packets being masqueraded (source NATed) through the MCR unit. For example, TCP traffic from a private host arriving at Local Ethernet interface, being masqueraded to the cellular interface's IP address before being sent out the cellular interface.

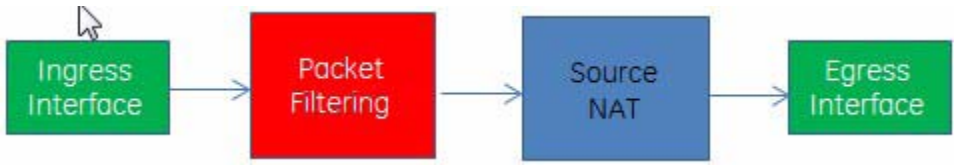


Figure 20. Packets Being Masqueraded Through MCR

Packet Filtering

Understanding

Packet filtering allows configuring and applying a packet filter (also called Access Control List, or ACL) to incoming or outgoing traffic on an interface. A filter is a set of one or more rules. Each rule consists of two parts:

- Matching criteria that a packet must satisfy for the rule to be applied. Matching criteria consists of various parameters like protocol, source/destination addresses and ports etc
- Actions that specify what to do with the packet when the matching criteria is met, for example, to drop or accept the packet.

The filter can then be applied to an interface in the incoming or outgoing direction. Note that typically, different filters are applied in the incoming and outgoing direction on an interface. For example, a filter applied to the cellular (WAN) interface of the MCR is typically very restrictive, permitting only a small set of traffic to enter the MCR, where as outgoing filter might permit all outgoing traffic etc.

NOTE: If the firewall service is enabled and no filter is applied to an interface, then both incoming and outgoing traffic is dropped on that interface.

Configuring

Configuration Hierarchy

NOTE: The configuration parameters shown here are a subset of all available configuration parameters. Refer to the appendix for a complete listing.

```
firewall {
```

```
enabled <true|false>;
filter <name> {
   rule <id> {
      match {
         protocol <icmp|udp|tcp|esp|all>;

         src-address {
            address <network/prefix> or address-range;
         }
         src-port {
            services [ <name1> <name2> …] or port-range;
         }
         dst-address {
            address <network/prefix> or address-range;
         }
         dst-port {
            services [ <name1> <name2> …] or port-range;
         }
         ipsec {
            direction  <in|out>;
            tunnel-src-address  <network/prefix>;
            tunnel-dst-address  <network/prefix>;
         }
      }
      actions {
         action <accept|drop|reject>;
         reject-type <net-unreachable|…>;
         log {
            level  <debug|info|…>;
            prefix <string>;

interfaces {
   interface <name> {
      filter {
         input  <name>;
         output <name>;
```

Packet filter configuration on MCR involves following high level steps:

1. Create a filter, decide on default policy of the filter. For example, there are usually two ways to organize a filter:
    a. Create a “restrictive” filter i.e. the last rule in the filter (also called “default policy” of filter) is to deny traffic and rules are added to specifically permit the traffic. For example,
        i. Rule 1 = permit protocol=tcp, dst port=22
        ii. Rule 2 = permit protocol=icmp
        iii. Rule 3 = deny everything
    b. Or Create a “permissive” filter i.e. the last rule in the filter (also called “default policy” of filter) is to permit traffic and rules are added to specifically deny traffic. For example,
        i. Rule 1 = deny protocol=tcp, dst port=80
        ii. Rule 2 = deny protocol=icmp
        iii. Rule 3 = permit everything
2. Apply the filter to input or output direction of the interface.

The following example describes the step-by-step configuration of an example filter that can be applied to cellular interface of the MCR. Change to CLI configuration mode:

1. Enable firewall service

   admin@(none) 19:33:20% set services firewall enabled true

2. Create a “restrictive” filter named “IN_UNTRUSTED” to indicate that this filter has been designed to be applied to an untrusted cellular interface of MCR. The cellular interface can be considered untrusted as it is connected to public cellular network, which is inherently an untrusted network.

   admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED

3. Create rule to permit encrypted IPsec tunnel traffic i.e. traffic with protocol=ESP

   admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 1 match protocol esp
   admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 1 actions action accept

4. Create rule to permit traffic for the following UDP services: DNS, NTP and IKE (to allow IPsec connection setup).

   admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 2 match protocol udp src-port services [dns ike ntp]

   admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 2 actions action accept

5. Create rule to permit traffic for following TCP services: SSH and NETCONF (to allow management of MCR):

   admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 3 match protocol tcp dst-port services [netconf ssh]

   admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 3 actions action accept

NOTE: The above rule permits SSH or NETCONF connection addressed to the cellular interface’s IP address. If it is desired that SSH or NETCONF connection only be allowed via the VPN tunnel, then ipsec match criteria described *below* should be used instead of above rule.

admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 3 match ipsec direction in tunnel-src-address 10.150.1.1/32 tunnel-dst-address 10.150.1.10/32

admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 3 actions action accept

Above example assumes cell interface’s IP address is 10.150.1.10 and VPN Gateway’s IP address is 10.150.1.1.

6. Create the last rule for this “restrictive” filter to deny everything else. Note that rules are applied in ascending order using rule IDs. Any rules added after this last rule will have no effect, as they would match “any” traffic, and be dropped. In this example rule ID 10 is chosen. This facilitates the insertion of new rules prior to this last one to support future new traffic types.

   admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 10 match protocol all

   admin@(none) 19:33:20% set services firewall filter IN_UNTRUSTED rule 10 actions action drop

7. Apply this filter to incoming direction on cellular interface “eth1”.

   admin@(none) 19:33:20% set interfaces interface eth1 filter input IN_UNTRUSTED

8. Create a “permissive” filter that permits all traffic. Later on, if needed, this filter can be enhanced to deny certain traffic from getting out of the cellular interface.

   admin@(none) 19:33:20% set services firewall filter OUT_UNTRUSTED rule 10 match protocol all
   admin@(none) 19:33:20% set services firewall filter OUT_UNTRUSTED rule 10 actions action accept

9. Apply this filter to outgoing direction on cellular interface “eth1”.

   admin@(none) 19:33:20% set interfaces interface eth1 filter output OUT_UNTRUSTED

10. Commit configuration and exit configuration mode.

    admin@(none) 19:33:20% commit
    admin@(none) 19:33:20% exit
    admin@(none) 19:33:20>

Monitoring

At this time there are no commands to monitor traffic statistics for packets being dropped or permitted by the firewall. This feature may be added to future revisions of firmware.

Network Address Translation (NAT)

Understanding

Network address translation allows one to map private IP addresses to public IP addresses and vice versa. There are two basic kinds of network address translation:

- Source NAT
- Destination NAT

Source NAT

Source NAT performs translation of source IP address of the traffic egressing an interface. This is typically used to provide many-to-one translation (also called masquerading) of a private network behind MCR to allow hosts on that private network to access a host (say HOST-B) on the public network. (See Figure 21.) All traffic originating from hosts in the private network will appear to have originated from a single IP address (the ip address of the public interface of the MCR, typically, cellular interface) from HOST-B's point of view. To allow return IP traffic for UDP/TCP connections, to be delivered to right private host, the MCR also performs source port translation. Therefore, masquerading consists of Network Address and Port Translation (NAPT).

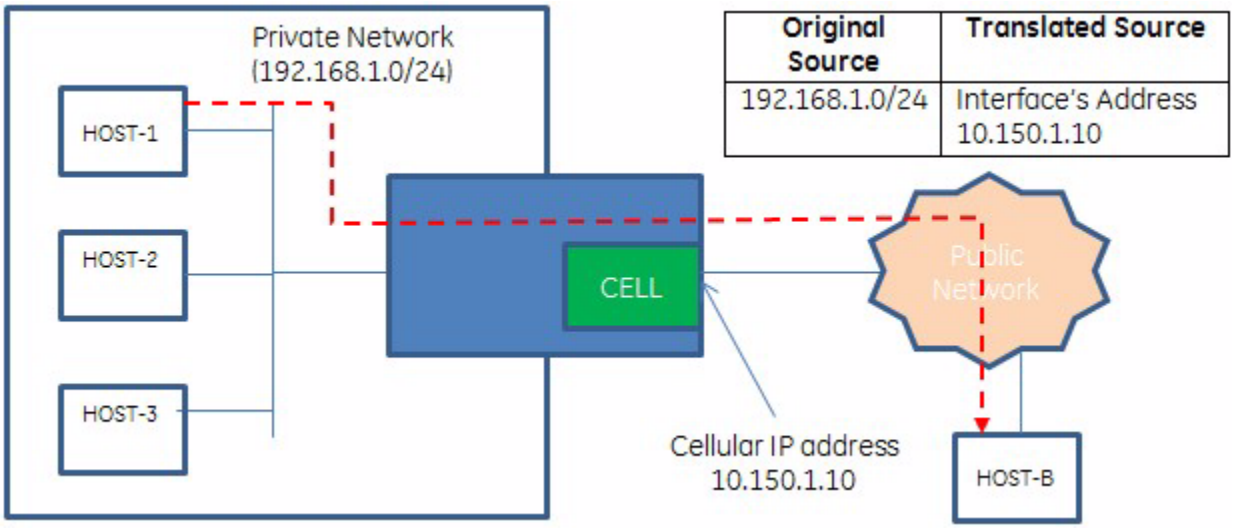


Figure 21. Source NAT Translation of IP Address

Configuring

Configuration Hierarchy

```
services {
   firewall
      nat {
         source {
            rule-set <name> {
               rule <id> {
                  match {
                     src-address <network/prefix>;
                     dst-address <network/prefix>;

                  }
                  source-nat {
                     interface;
                  }
               }
            }
         }
      }
}

interfaces {
   interface <name> {
      nat {
         source  <name>;
      }
   }
}
```

Source NAT configuration on MCR involves following high level steps:

1. Create a source NAT rule-set.
2. Add rule to perform source NAT on the public interface.
3. Apply the source NAT rule-set to the public interface.

Following example describes the step-by-step configuration of an example source NAT rule-set to perform masquerading on cellular interface of MCR. Change to CLI configuration mode:

1. Enable firewall service, if it is not already enabled.

   admin@(none) 19:33:20% set services firewall enabled true

2. Create source NAT rule-set named MASQ.

   admin@(none) 19:33:20% set services firewall nat source rule-set MASQ

3. Create rule for masquerading

   admin@(none) 19:33:20% set services firewall nat source rule-set MASQ rule 1 source-nat interface

4. Apply this source NAT rule-set to cellular interface.

   admin@(none) 19:33:20% set interfaces eth1 nat source MASQ

5. Commit configuration and exit configuration mode.

   admin@(none) 19:33:20% commit
   admin@(none) 19:33:20% exit
   admin@(none) 19:33:20>

Monitoring

At this time there are no commands to monitor traffic statistics for packets being masqueraded by the firewall. This feature might be added in future revisions of firmware.

Destination NAT

Destination NAT performs translation of destination IP address (and, optionally, destination port) of the traffic ingressing an interface. This is typically used to allow a host on the public network (HOST-B) to access a service running on a host in the private network (HOST-1). This is also called port forwarding.

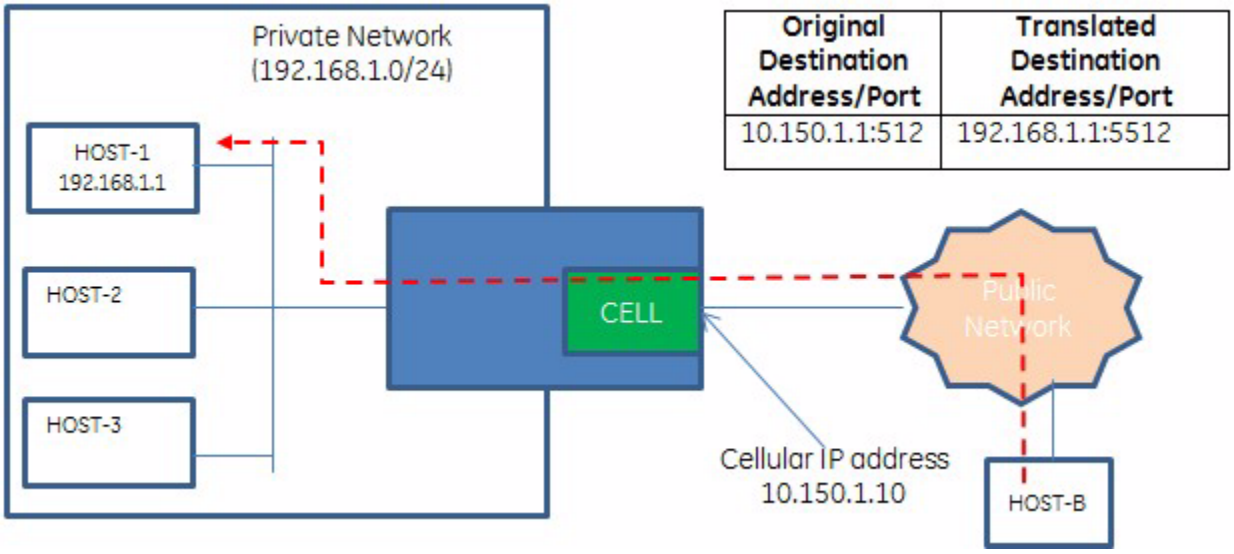


Figure 22. Destination NAT Translation of IP Address

Configuring

Configuration Hierarchy

```
services {
   firewall
      nat {
         destination {
            rule-set <name> {
               rule <id> {
                  match {
                     protocol <udp|tcp>
                     src-address <network/prefix>;
                     dst-address <network/prefix>;
                     dst-port <unit16>;
                  }
                  destination-nat {
                     address <ip-address>;
                     port <unit16>;
                  }
               }
            }
         }
      }
}
interfaces {
   interface <name> {
      nat {
         destination  <name>;
      }
   }
}
```

Destination NAT configuration on MCR involves following high level steps:

1. Create a destination NAT rule-set.

2. Add one or more rules to perform destination NAT for a specific incoming traffic on the public interface.

3. Apply the destination NAT rule-set to the public interface.

Following example describes the step-by-step configuration of an example destination NAT rule-set to perform port forwarding for incoming Modbus protocol (TCP port 512) traffic on the cellular interface to the private HOST-1 (assume that modbus traffic is running on port 5512 on HOST-1). Change to CLI configuration mode:

1. Enable firewall service, if it is not already enabled.

   admin@(none) 19:33:20% set services firewall enabled true

2. Create source NAT rule-set named IO_SERVICES.

   admin@(none) 19:33:20% set services firewall nat destination rule-set IO_SERVICES

3. Create rule for port forwarding Modbus TCP traffic coming into cellular interface on port 512 to port 5512 on private HOST-1.

   admin@(none) 19:33:20% set services firewall nat destination rule-set IO_SERVICES rule 1 match protocol tcp dst-address 10.150.1.1/32 dst-port 512

   admin@(none) 19:33:20% set services firewall nat destination rule-set IO_SERVICES rule 1 destination-nat address 192.168.1.1 port 5512

4. Apply this destination NAT rule-set to cellular interface.

   admin@(none) 19:33:20% set interfaces eth1 nat destination IO_SERVICES

5. Commit configuration and exit configuration mode.

   admin@(none) 19:33:20% commit
   admin@(none) 19:33:20% exit
   admin@(none) 19:33:20>

Monitoring

At this time there are no commands to monitor traffic statistics for packets being masqueraded by the firewall. This feature may be added in future revisions of firmware.

VPN

Understanding

The MCR supports standards-based IPsec Virtual Private Network (VPN) technology to securely connect remote private network (LAN or WiFi) with the customer's backoffice/data center private network see Figure 23). This allows IP traffic from/to devices connected to either LAN, WiFi or Serial port of the MCR to securely flow to/from back-office applications via a secure tunnel through a public cellular network. The tunneled application traffic is authenticated and encrypted to protect from eavesdropping, tampering and replay attacks.

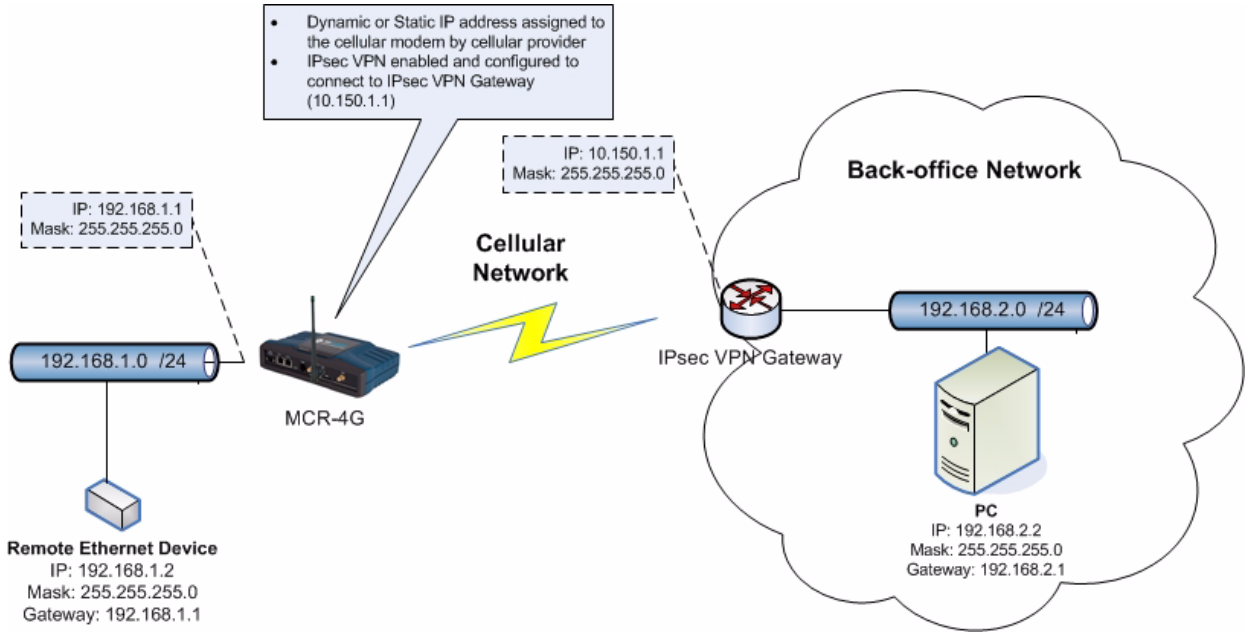


Figure 23. VPN Setup Example

Figure 23 shows an example network, where a remote Ethernet device is connected to MCR via Ethernet on 192.168.1.0/24 network. The MCR establishes a VPN connection with IPsec VPN gateway, thereby securely connecting remote private network (192.168.1.0/24) with back-office private network (192.168.2.0/24). This allows PC (192.168.2.2) to communicate with remote Ethernet device (192.168.1.2) using any TCP/UDP/IP based protocol and vice versa.

IPsec, Internet Protocol Security, is a set of protocols defined by the IETF, Internet Engineering Task Force, to provide IP security at the network layer.

An IPsec based VPN is made up by two parts:

- Internet Key Exchange protocol (IKE)
- IPsec protocols (ESP, AH)

The first part, IKE, is the initial negotiation phase, where the MCR and VPN gateway agree on which methods will be used to provide security for the underlying IP traffic. There are two IKE protocol versions: IKE-v1 and IKE-v2. These are not compatible with each other. The IKE-v2 is more efficient and therefore should be preferred for new deployments. The MCR supports IKE-v1 and IKE-v2.

The other part is the actual IP data being transferred, using the encryption and authentication methods agreed upon in the IKE negotiation. This is accomplished by using IPsec protocols like Encapsulating Security Payload (ESP) or Authentication Header (AH). The MCR only supports ESP protocol as it provides both encryption and authentication of the data. The AH protocol provides only data authentication.

The process of IPsec VPN connection establishment consists of following phases:

- IKE Phase-1 (IKE security negotiation)
  - Negotiate how IKE should be protected
- IKE Phase-2 (IPsec Security Association)
  - Negotiate how IPsec should be protected
  - Derive fresh keying material from the key exchange in phase-1, to provide session keys to be used in the encryption
  - and authentication of the VPN data flow
- Exchange data over the IPsec tunnel

Both the IKE and the IPsec connections have limited lifetimes. These lifetimes prevent a connection from being used too long, which is desirable from a cryptanalysis perspective.

The IPsec lifetime is generally shorter than the IKE lifetime. This allows for the IPsec connection to be re-keyed simply by performing another phase-2 negotiation.

Configuring VPN

VPN Configuration Hierarchy

NOTE: The configuration parameters shown here are a subset of all available configuration parameters. Refer to the appendix section for all available parameters.

```
services {
    vpn {
        enabled <true|false>;
            ike {
                policies {
                    policy <name> {
                            auth-method <eap-tls|eap-ttls|pre-shared-key|pub-key>;
                            pki {
                                cert-type  <rsa|ecdsa>;
                                cert-id    <certificate-id>;
                                key-id     <private-keyid>;
                                ca-cert-id <ca-certificate-id>;
                            }
                            ciphersuites {
                                ciphersuite <name> {
                                    encryption-algo <aes-256-cbc|….>;
                                    mac-algo        <sha256-hmac|….>;
                                    dh-group        <dh-14|….>;
                                }
                            }
                        }
                        peers {
                            peer <name> {
                            ike-policy  <reference-to-ike-policy>;
                            peer-endpoint {
                                address <ip-address>;
                            }
                            peer-identity-no-idr <true|false>;
                            role   <initiator|responder>;
                            dpd-interval <interval (secs)>
                        }
                    }
                            }
                ipsec {
                    policies {
                        policy <name> {
                            ciphersuites {
                                ciphersuite <name> {
                                encryption-algo <aes-256-cbc|…>;
                                mac-algo        <sha256-hmac|…>;
                                dh-group        <dh-14|…>;
                            }
                        }
                    }
                    connections {
```

```
                connection <name> {
                    ike-peer            <reference-to-ike-peer>
                    ipsec-policy        <reference-to-ipsec-policy>;
                    local-ip-subnet     <x.x.x.x/len>;
                    remote-ip-subnet    <y.y.y.y/len>;
                    failure-retry-interval 1;
                    is-out-of-band-ima <true|false>
                }
            }
        }
}
```

Firewall Filters for the Cellular Interface

When setting up IPsec VPN over a Cellular interface, the following firewall filters are recommended to be configured and applied to the cellular interface. The **IN_UNTRUSTED** and **OUT_UNTRUSTED** filters should be applied to incoming and outgoing traffic respectively.

```
filter IN_UNTRUSTED {
   rule 1 {
      match {
         protocol udp;
         src-port {
            services [ dns ike ntp ];
         }
      }
      actions {
         action accept;
      }
   }
   rule 2 {
      match {
         protocol esp;
      }
      actions {
         action accept;
      }
   }
   rule 3 {
      match {
         protocol icmp;
      }
      actions {
         action accept;
      }
   }
   rule 4 {
      match {
         ipsec {
            direction         in;
            tunnel-src-address <VPN SERVER IP ADDRESS>/32;
            tunnel-dst-address <CELL INTERFACE IP ADDRESS>/32;
         }
      }
      actions {
         action accept;
      }
   }
   rule 10 {
      match {
         protocol all;
      }
      actions {
         action drop;
      }
   }
}
filter OUT_UNTRUSTED {
   rule 1 {
      match {
         src-address {
            address <CELL INTERFACE IP ADDRESS>/32;
         }
```

```
      }
      actions {
         action accept;
      }
   }
   rule 2 {
      match {
         ipsec {
            direction        out;
            tunnel-src-address <CELL INTERFACE IP ADDRESS>/32;
            tunnel-dst-address <VPN SERVER IP ADDRESS>/32;
         }
      }
      actions {
         action accept;
      }
   }
   rule 10 {
      match {
         protocol all;
      }
      actions {
         action drop;
      }
   }
}
```

VPN configuration involves the following high level steps:

1. Configure an IKE policy specifying an authentication method, cipher suites to be included in the proposal during IKE phase-1 and the credentials to be used for authentication e.g. certificates or preshared-keys.

2. Configure an IKE peer specifying peer endpoint address, IKE policy to used for IKE phase-1 negotiation. The “role” specifies whether MCR initiates connection (initiator) or it waits for the connection from the peer (responder). This should usually be set to “initiator”.

3. Configure an IPsec policy specifying ESP cipher suites to be included in the proposal during IKE phase-2.

4. Configure an IPsec connection specifying IKE peer, IPsec policy, local and remote private IP subnets.

NOTE: The above configuration parameters should match with the corresponding parameters set in the peer. Otherwise, the IPsec VPN connection will not succeed. Typical configuration mistakes include incorrect security credentials (psk or certificates/keys), mismatched cipher suite configuration, and mismatched local and remote subnet configuration**.**

The following example describes the step-by-step VPN configuration for the example network shown in figure above. We’ll assume that certificates are being used as security credentials and have already been loaded in the MCR either manually or via SCEP.

1. Ensure that cellular interface has been configured.

2. Ensure that device has been configured with certificates/keys.

3. Ensure that device has been configured to obtain time via NTP.

NOTE: The VPN connection will fail unless the time is synchronized on the device because certificate validation will fail.

---

4. Enable VPN service

admin@(none) 20:38:44% set services vpn enabled true

5. Create IKE policy with auth-method “public-key encryption”.

admin@(none) 19:33:29% set services vpn ike policies policy IKE-POLICY-1 auth-method pub-key

6. Configure Public Key Infrastructure (PKI) security credentials

   a. Certificate type as “rsa” if RSA public key encryption based certificates are being used.

   b. Client certificate ID – This is the ID that was assigned to the client certificate obtained via SCEP or loaded manually.

   c. Client private key ID – This is the ID that was assigned to the client private key generated during SCEP procedure or loaded manually.

   d. Certificate Authority (CA) certificate ID – This is the ID that was assigned to the CA certificate obtained via SCEP or loaded manually.

admin@(none) 19:33:29% set services vpn ike policies policy IKE-POLICY-1 pki cert-type rsa
admin@(none) 19:33:29% set services vpn ike policies policy IKE-POLICY-1 pki cert-id ID-1
admin@(none) 19:33:29% set services vpn ike policies policy IKE-POLICY-1 pki key-id ID-1
admin@(none) 19:33:29% set services vpn ike policies policy IKE-POLICY-1 pki ca-cert-id GEPKI

1. Configure the following ciphersuite to be included as proposal for IKE phase-1 negotiation:

   a. Encryption Algorithm = AES 256 Bit in CBC mode

   b. Message Authentication Algorithm = HMAC using SHA256 digest

   c. Diffie-Hellman Group = DH-14 (group 14 modp2048)

admin@(none) 19:33:29% set services vpn ike policies policy IKE-POLICY-1 ciphersuites ciphersuite AES256_CBC-SHA256-DH14 encryption-algo aes-256-cbc

admin@(none) 19:33:29% set services vpn ike policies policy IKE-POLICY-1 ciphersuites ciphersuite AES256_CBC-SHA256-DH14 mac-algo sha256-hmac

admin@(none) 19:33:29% set services vpn ike policies policy IKE-POLICY-1 ciphersuites ciphersuite AES256_CBC-SHA256-DH14 dh-group dh-14

NOTE: More than one ciphersuite can be included in the proposal.

---

1. Create IKE peer with address 10.150.1.1 and dead peer detection enabled and interval set to 5 mins.

The dead peer detection (DPD) is enabled by default. When enabled, it sends **R_U_THERE/INFORMATIONAL** messages to the peer if there no other data sent within DPD interval. This allows MCR to detect dead VPN peers and clear a VPN connection. The DPD interval should be set to no less than 300 seconds (5 minutes) to reduce the periodic traffic in the network.

The peer-identity-no-idr parameter, when set to true, prevents the unit from sending the responder’s ID (IDr) in its **IKE_AUTH** request which might prevent the peer from finding matching a configuration.

admin@(none) 19:33:29% set services vpn ike peers peer VPN-GW role initiator

admin@(none) 19:33:29% set services vpn ike peers peer VPN-GW ike-policy IKE-POLICY-1

admin@(none) 19:33:29% set services vpn ike peers peer VPN-GW peer-endpoint address 10.150.1.1

admin@(none) 19:33:29% set services vpn ike peers peer VPN-GW peer-identity-no-idr true

admin@(none) 19:33:29% set services vpn ike peers peer VPN-GW dpd-interval 300

2. Create an IPsec policy and configure the following ciphersuite to be included as proposal for IKE phase-2 negotiation:
   - Encryption Algorithm = AES 256 Bit in CBC mode
   - Message Authentication Algorithm = HMAC using SHA256 digest
   - Diffie-Hellman Group = DH-14 (group 14 modp2048)

admin@(none) 19:33:29% set services vpn ipsec policies policy IPSEC-POLICY-1 ciphersuites ciphersuite AES256_CBC-SHA256-DH14 encryption-algo aes-256-cbc

admin@(none) 19:33:29% set services vpn ipsec policies policy IPSEC-POLICY-1 ciphersuites ciphersuite AES256_CBC-SHA256-DH14 mac-algo sha256-hmac

admin@(none) 19:33:29% set services vpn ipsec policies policy IPSEC-POLICY-1 ciphersuites ciphersuite AES256_CBC-SHA256-DH14 dh-group dh-14

NOTE: More than one ciphersuite can be included in the proposal.

3. Create IPsec connection

admin@(none) 19:33:29% set services vpn ipsec connections connection VPN-GWY-CONN-1 ike-peer VPN-GWY

admin@(none) 19:33:29% set services vpn ipsec connections connection VPN-GWY-CONN-1 ipsec-policy IPSEC-POLICY-1

admin@(none) 19:33:29% set services vpn ipsec connections connection VPN-GWY-CONN-1 local-ip-subnet 192.168.1.0/24

admin@(none) 19:33:29% set services vpn ipsec connections connection VPN-GWY-CONN-1 remote-ip-subnet 192.168.2.0/24

admin@(none) 19:33:29% set services vpn ipsec connections connection VPN-GWY-CONN-1 failure-retry-interval 1

The following table describes the VPN connection attempt retries and time interval between them. After giving up as listed below, the unit waits for “failure-retry-interval” and repeats the connection attempt sequence.

Attempt#	Relative Timeout between attempts (in secs)	Absolute Timeout from first attempt (in secs)
1	0	0
2 (1st retry)	4	4
3 (2nd retry)	7	11
4 (3rd retry)	13	24
5 (4th retry)	23	47
6 (5th retry)	42	89
give up	76	165
Wait for “failure-retry-interval”, then repeat above sequence		

During initial configuration set failure-retry-interval to lowest value of 1 min, to have MCR attempt connection more quickly. This allows debugging of any connection-related issue by watching logs on peer side etc. Be sure to change this value to 5 mins or higher to prevent excessive attempts and traffic.

4. Commit configuration and exit configuration mode.

admin@(none) 20:38:44% commit

```
admin@(none) 20:38:44% exit
[ok][2013-01-18 20:40:45]
admin@(none) 20:38:44>
```

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the VPN connection state (connecting, connected or disconnected). The failure-reason displays the reason for last connection failure.

```
admin@(none) 20:40:45> show services vpn
services vpn ipsec ipsec-status connections connection VPN-GWY-CONN-1
 state     connecting
 failure-reason     none
 last-timestamp     2013-01-18T20:24:15+00:00
 ima-evaluation     none
 ima-recommendation none

admin@(none) 20:40:45> show services vpn
services vpn ipsec ipsec-status connections connection VPN-GWY-CONN-1
 state           connected
 failure-reason     none
 last-timestamp     2013-01-18T20:24:15+00:00
 ima-evaluation     none
 ima-recommendation none
```

With a connection made, ping the back-office PC to make sure the traffic is passing between device and PC.

```
admin@(none) 20:41:32> ping 192.168.2.1
PING 192.168.1.2 (192.168.2.1) 56(84) bytes of data.
64 bytes from 192.168.2.1: icmp_req=1 ttl=63 time=389 ms
64 bytes from 192.168.2.1: icmp_req=2 ttl=63 time=161 ms
[ok][2013-01-18 20:49:42]
```

VPN Troubleshooting

The following are common reasons for VPN connection failure:

1. Invalid certificate or keys loaded on the device

2. Time not synchronized on the device. Note that after cell connection is established, device can take few minutes to sync time from NTP server. VPN connection will not succeed until time is synchronized.

3. Mismatch in ciphersuites configured for IKE policy on device and peer VPN gateway.

4. Mismatch in ciphersuites configured for IPsec policy on device and peer VPN gateway.

5. Mismatch in remote and local IP subnets configured for IPsec connection on device and peer VPN gateway. Note the following:
    a. for device
        i. remote ip subnet = back-office subnet
        ii.local ip subnet = local LAN or WIFI subnet on device
        iii.
    b. for VPN gateway
        i. remote ip subnet = device’s local LAN or WIFI subnet
        ii.local ip subnet = back-office subnet on device
        iii.

DNS

Understanding

Domain Name System (DNS) servers can be configured on the unit to facilitate the resolution of domain names to IP addresses.

NOTE: Manual configuration of DNS overrides any DNS settings obtained via DHCP.

Configuring

The following example shows how to configure a DNS server with IP address 192.168.1.2 on the MCR. Note that the "search" option can take a list of arguments and in this example, there are two arguments; **mds** and **gemds**.

```
admin@(none) 00:31:02% set system dns server 192.168.1.2 search [ mds gemds ] options attempts 3
timeout 3
```

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state and statistics.

The *ping* utility can be used on the CLI when it is in operational mode to verify that DNS is working properly. If ping can resolve a name on the connected network to an IP address then DNS settings are working properly. The example below shows the resolution of the name "example.com" to the IP address "192.0.43.10" on a unit that is connected to the Internet.

Use the control sequence "CTRL-C" to stop the ping utility.

```
admin@(none) 00:20:33> ping example.com
PING example.com (192.0.43.10) 56(84) bytes of data.
64 bytes from 43-10.any.icann.org (192.0.43.10): icmp_req=1 ttl=237 time=30.8 ms
64 bytes from 43-10.any.icann.org (192.0.43.10): icmp_req=2 ttl=237 time=44.7 m
[ok][2012-06-19 00:24:08]
admin@(none) 00:24:08>
```

DHCP Service

Understanding

The unit can be configured to act as a DHCP server. When enabled, this service will respond to DHCP requests from any interface.

Configuring

The following shows an example of configuring DHCP service on the unit. The unit will administer IPv4 addresses from the 192.168.x.x network when requests are received from DHCP clients.

NOTE: At least one of the unit's interfaces (eth0 or br0 if eth0 is bridged) must be configured with an IP address from this subnet.

```
admin@(none) 04:18:26% set services dhcp v4subnet 192.168.0.0/16 domain-name gemds range-start
192.168.1.100 range-end 192.168.1.150 router 192.168.1.1 broadcast-address 192.168.255.255
ntp-servers [ time.mds ]
```

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the DHCP leases.

```
admin@(none) 04:18:26> show services dhcp

services dhcp leases 192.168.1.100
 starts       2013-01-22T12:55:13+00:00
 ends         2013-01-23T00:55:13+00:00
 binding-state free
 client-mac   70:f1:a1:fc:1d:da
 hostname     ""
[ok][2013-01-23 04:18:27]
```

Terminal Service

Understanding

The unit allows the setup of the COM ports as a terminal server that passes data to/from the serial port to network interfaces. The serial port must be configured to do this, in addition to the baud rate and data format. The data from the serial port is treated as a seamless stream; meaning it is not protocol aware and will send data from the serial port to the remote endpoint as soon as the data is received.

A terminal-server can consist of a TCP server, a TCP client, or a UDP endpoint, and a MODBUS-TCP server.

When a terminal server on the unit is configured as TCP server, then the unit listens on a TCP port for client connections. When a terminal server on the unit is configured as TCP client, then the unit will attempt to connect to the remote IP address. Once a TCP connection is established, then serial traffic from the COM port can pass to and from the TCP port as long as the TCP connection remains established.

When a terminal server on the unit is configured as a UDP endpoint, then traffic from the COM port is sent to the remote host at the specified port in UDP packets. Likewise, traffic sent to the UDP port of the unit is forwarded out the COM port. Since UDP is stateless, some packets may not reach their intended destination or may arrive out of order. The protocol contained in the UDP messages must handle these scenarios.

NOTE: Once a terminal-server is enabled on a COM port, the port stays in data mode and the CLI will not be available on that port. To break out of data mode, the escape sequence **+++** can be entered on the PC's keyboard. The baud rate and format must match on the PC and on the unit for the escape sequence to be detected. Once the sequence is detected, the login prompt is presented as long as the port is enabled for console access.

Configuring

The following shows how to enable a UDP terminal server on COM1

```
admin@(none) 01:34:45% set services serial terminal-server server COM1 mode udp port 10000
remote address 192.168.1.12 port 10000

[ok][2012-06-19 01:35:36]

[edit]
admin@(none) 01:35:36% commit
```

The following shows how to enable a TCP terminal server on COM1

```
admin@(none) 01:22:09% set services serial terminal-server server COM1 mode tcp-server port 30011
idle-timeout 30

[ok][2012-06-19 01:22:36]
[edit]
admin@(none) 01:22:36% commit
```

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state and statistics:

```
admin@(none) 22:03:06> show services serial

                                                SERIAL   SERIAL  SERIAL   SERIAL
SERIAL   IP TX    IP TX  IP RX    IP RX  TX       TX      RX      RX
PORT     PACKETS  BYTES  PACKETS  BYTES  PACKETS  BYTES   PACKETS  BYTES
-------------------------------------------------------------------------------
COM2     0        0      0        0      0        0       0        0

[ok][2013-01-24 22:03:13]
```

Iperf Service

Understanding

Iperf service allows one to receive TCP traffic from remote host running iperf. Currently, iperf service is hardcoded to act only as a TCP server listening on port 5001.

Configuring

The following shows how to enable iperf service:

```
admin@(none) 22:04:32% set services iperf enabled true
admin@(none) 22:04:32% commit
```

NOTE: If firewall is enabled, then it must be configured to permit incoming TCP traffic on port **5001.**

Monitoring

Ensure the CLI is in operational mode. Follow the example to view the state of iperf service:

```
admin@(none) 22:07:37> show services

NAME              STATUS
---------------------------
DHCP Server       running
Firewall          running
IPerf Server      running
Terminal Server   running
VPN               running
```

Date, time and NTP

Understanding

The date and time can be set on the MCR using a manually configured value or automatically via Network Time Protocol (NTP). The NTP settings take precedence over the manual settings. If NTP is enabled, then the user will not be able to set the date and time manually.

Configuring

To manually set the date and time, use the request set-current-datetime:

admin@(none) 18:18:58> request system clockset set-current-datetime current-datetime <time>

To use an NTP server, an NTP server must be configured on MCR:
admin@(none) 00:20:33% set system ntp use-ntp true ntp-server time.nist.gov
admin@(none) 00:20:33% commit

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state and statistics:

admin@(none) 00:20:34> show system clock
system clock current-datetime 2012-06-19T00:20:34+00:00
system clock boot-datetime 2012-06-19T00:18:01+00:00
[ok][2012-06-19 00:20:34]

Geographical-location

The geographical-location of the unit can be configured as shown below:

```
admin@(none) 00:50:46% set system geographical-location altitude 1.0 latitude 43.117807 longitude
-77.611896

[ok][2012-06-19 00:56:00]

[edit]
admin@(none) 00:56:00% commit
Commit complete.
[ok][2012-06-19 00:56:05]

[edit]
admin@(none)
```

User Management and Access Controls

Understanding

There are three user accounts/roles (admin, technician, and operator) for management access.

Users in the *admin* group have the highest privilege and can read everything in the tree that is readable, write everything that is writable, and can execute any of the requests.

Users in the *tech* group have less access than admin. Generally, the tech group cannot configure any security related configuration.

Users in the *oper* group can only view status and configuration. They do not have access to modify the device configuration.

By default, the password for each account is the same as the username. The passwords should be changed by users prior to deploying the device. When local user management is being used, passwords are stored in non-volatile memory using PKCS#5 based encryption.

The user authentication can be done using locally stored passwords or via RADIUS.

Configuring

The password for each user account can be changed using a request:

```
admin@(none) 01:04:19> request system authentication change-password user admin password
new_password
```

User authentication order can be specified to give preference to which method is used first when authenticating user access. In the following example, the list of RADIUS servers will be contacted first before the local authentication rules are used.

NOTE: If the local-users option is specified *before* RADIUS, then only the local-users option will be utilized; the RADIUS servers will never be contacted.

```
admin@(none) 01:05:07% set system authentication user-authentication-order [ radius local-users ]

admin@(none) 01:05:07% commit
```

Monitoring

Ensure the CLI is in operational mode. Follow the example below to see the history of login attempts by reviewing the event log:

```
admin@(none) 01:21:48> show logging event-log event-type console_login
logging event-log 62625
 time-stamp 2011-12-21T01:18:08.985996+00:00
```

```
 priority   notice
 event-type console_login
 status     success
 message    “user_name oper, “
logging event-log 62627
 time-stamp 2011-12-21T01:23:00.288046+00:00
 priority   notice
 event-type console_login
 status     failure
 message    “msg noauth, user_name admin, “
[ok][2011-12-21 01:23:03]
admin@(none) 01:23:03>
```

Login-Lockout

Understanding

The unit has protections against repeated login attempts. The max-login-attempts configuration determines the number of failed logins that can occur in succession before the unit disables the ability to login for a specified amount of time. The amount of time is determined by failed-login-lockout-time, which represents the time in seconds.

Configuring

admin@(none) 01:51:26% set system max-login-attempts 30
[ok][2012-06-19 01:56:38]

[edit]
admin@(none) 01:56:38% set system failed-login-lockout-time 300
[ok][2012-06-19 01:56:56]

[edit]
admin@(none) 01:56:56% commit

RADIUS

Understanding

User accounts can be centrally managed with a RADIUS server. RADIUS accounts can be mapped to one of the three user roles.

If the RADIUS server is not accessible, users may use the local username/password to "fall back" to local authentication if the unit is configured to do so. Many RADIUS servers do not respond to a failed login attempt. To the unit, this appears the same as if the server is not there. The consequence of this behavior is that after three failed login attempts, the authentication will take place against the local user/password database if local fallback is enabled. Refer to the section on "Local User Management" for configuring the authentication order.

If more than one RADIUS server is configured, then the unit will attempt each RADIUS server in the order that they appear in the configuration until a successful response is received. A RADIUS server must be configured to provide the user's authentication group in its authentication reply via a GE MDS vendor attribute. This can be configured in freeradius (an open source RADIUS server) by using the following dictionary file:

```
VENDOR GEMDS 4130
BEGIN-VENDOR    GEMDS
ATTRIBUTE GEMDS-UserAuth-Group 1 integer
VALUE     GEMDS-UserAuth-Group Operator       0
VALUE     GEMDS-UserAuth-Group Technician     1
VALUE     GEMDS-UserAuth-Group Administrator  2
END-VENDOR GEMDS
```

And configuring users as follows:

```
admin Cleartext-Password := "admin"
      GEMDS-UserAuth-Group := Administrator

tech Cleartext-Password := "tech"
      GEMDS-UserAuth-Group := Technician

oper Cleartext-Password := "oper"
      GEMDS-UserAuth-Group := Operator
```

Configuring

The following shows how to configure a RADIUS server:

```
admin@(none) 02:23:42% set system mds-radius servers server1 address 192.168.1.2 shared-secret
abcd1234 user-authentication-type radius-CHAP

admin@(none) 00:06:15% show system mds-radius
servers server1 {
   address              192.168.1.2;
   shared-secret        abcd1234;
   user-authentication-type radius-CHAP;
}
[ok][2012-06-19 00:06:22]

[edit]
admin@(none) 00:06:22%commit
```

File Servers

Understanding

External file servers can be preconfigured so that the configuration can easily be referenced in other services without the need to re-enter the information. File Server Configurations can be used for reprogramming, downloading certificates, and sending support bundles for debugging.

Configuring

The following shows how to add a file server configuration named “GE File Server 1”:

```
admin@(none) 05:11:42% set file-servers GE_file_server_1tftp address 192.168.1.2
admin@(none) 05:11:42% commit


admin@(none) 03:24:45> show configuration file-servers
file-servers GE_file_server_1 {
   tftp {
      address 192.168.1.2;
   }
}
[ok][2012-06-19 03:24:50]
```

Monitoring

Ensure the CLI is in operational mode. The file transfer status is available as operational data. Refer to the sections on “Firmware Management” and “Certificate Management” for more information.

Certificate Management

Understanding

The unit uses X.509 public certificates and private keys for the following services:

- Secure Reprogramming
- Syslog over TLS
- IPsec VPN/IMA (when using pub-key, EAP-TLS or EAP-TTLS based authentication)
- WiFi (when doing EAP-TLS authentication in station mode)

Certificates can be loaded into the device using one of two methods: manual or SCEP. Note that certificates for secure reprogramming can only be loaded using the manual method.

The unit can load certificates that are in DER, PEM, or Encrypted PEM format. The unit can load private keys that are in DER, PEM, Encrypted PEM, or PKCS#8 format.

Configuring

From either operational or configuration mode, requests can be made on the device related to certificate management. Using the Tab character after entering 'request certmgr-' shows a list of the available requests.

```
admin@(none) 05:04:37> request pki
Possible completions:
   cancel-scep-operation - Cancel the last SCEP operation initiated.
  delete-cacert         - Delete identified CA certificate
  delete-clientcert     - Delete identified Client certificate
  delete-firmware-cert  - Delete identified certificate
  delete-priv-key       - Delete identified Private Key
  generate-priv-key     -
  get-ca-cert           - Request the certmgr to retrieve a CA cert from store.
  get-client-cert       - Request the certmgr to retrieve a client cert from
                          store.
  get-firmware-cert     - Install a certificate to be used for firmware
                          validation
  get-priv-key          - Retrieve private key file from network or local file
                          system.
  show-cert-info        - Dump identified certificate as text to display
```

Manual Download of Security Material

The 'get' series of requests allow security material to be downloaded from the network. The specifics of the communication can either be defined in the request or a server can be preconfigured separately (see section on "File Servers") and used in the request.

To manually load certificates from a file server, the following requests must be used:

- **certmgr-get-cacert – To load CA certificates**
- **certmgr-get-clientcert – To load device/client certificates**
- **certmgr-get-firmware-certificate – To load firmware verification certificates**
- **certmgr-get-priv-key – To load device/client private key**

When loading certificates manually, the file server from which the certificate will be retrieved must be provided. The file server configuration can be entered every time or, to reduce typing, the file server configuration can be selected from one of the preconfigured file servers (see "File Servers" section):

The following example shows loading of CA certificates using a file server defined prior to using the Certificate Manager request:

```
admin@(none) 01:19:31> request pki-get-cacert preconfigured-file-server { configuration_name
GE_file_server_1 } filename ms8-ca-cert cacert-identity ex_ca_cert_2

is-valid true
[ok][2012-06-19 01:20:03]
admin@(none) 01:20:03> show pki

KEY        KEY
IDENTITY   LENGTH  KEY DATE TIME
---------------------------------------
ex_key     2048    2012-06-20T10:46:59Z
```

Here is an example of defining the file server manually in-line with the request call:

```
admin@(none) 00:35:27> request pki-get-priv-key manual-file-server { tftp { address 192.168.1.2 } } file-
name der2048-priv-key key-identity ex_key_1

is-valid true
[ok][2012-06-19 00:36:27]
admin@(none) 00:36:27> show pki

KEY        KEY
IDENTITY   LENGTH  KEY DATE TIME
---------------------------------------
ex_key     2048    2012-06-20T10:46:59Z
ex_key_1   2048    2012-06-19T04:36:26Z
```

When defining a file server manually you may, as in this example, accept the defaults provided (in this example, block-size, port and timeout). After entering the address, a space and '}' must be entered to complete the parameters for the chosen mode. Always try the Tab-Enter to have the CLI show the next needed parameters.

SCEP and CA Configuration

The process of interacting with a SCEP server involves getting the currently published certificate(s) from the CA and then making a request for a client certificate with information and key material.

At a minimum, to get the published certificates from a CA, the SCEP server and the CA associated with the SCEP server must be identified:

- **certmgr certificate-servers**
- **certmgr ca-servers**

The certificate server is defined in the certmgr under certificate-server. In the operation shown below, we define the SCEP server.

```
admin@(none) 23:46:28> config
Entering configuration mode private
[ok][2012-06-22 23:46:35]

[edit]
admin@(none) 23:48:14% set pki certificate-servers certificate-server ex_scep_serv server-type scep
scep-server-setting scep-uri 192.168.1.5:12345/certserv/mscep/mscep.dll scep-poll-interval 5
scep-retry-count 120
[ok][2012-06-22 23:49:52]

[edit]
admin@(none) 23:49:52% commit
Commit complete.
[ok][2012-06-22 23:49:56]

[edit]
admin@(none) 23:49:56%%
```

This defines the server that is running the SCEP protocol on an accessible network. The unit will append an 'http://' to the URL so it *must not* be entered as part of the scep-uri parameter in the configuration. Note also, the above is just an example. Your IP address, specific port (if different from the default), and path to .dll or .cgi or other SCEP server mechanism must be obtained from your System Administration or Security personnel.

The configuration of the Certificate Authority that will be accessed at the above server is setup in a second command in certmgr under ca-servers.

```
admin@(none) 03:05:56% set pki ca-servers ca-server ex_ca_serv ca-identity my_ca ca-fingerprint
c1f2b0930c2c8e96164c3ed2d7e970a16860df8537403632dc18d7bf9bb7d546
[ok][2012-06-20 03:08:07]
[edit]
admin@(none) 03:08:07% commit
Commit complete.
[ok][2012-06-20 03:08:30]

[edit]
admin@(none) 03:08:30%
```

The fingerprint of the CA server is another data item you will obtain from your System Administrator or Security personnel. The ca-server name is the name that will be referenced in the SCEP operations described below. The ca-identity is part of the data that goes to the CA server. In general, it is simply for your reference and does not have to be a specific name. In fact, it can be the same name as the ca-server if this helps to remember it.

Also, client certificate information that goes in the “Subject” portion of an X.509 certificate must be configured. Some fields may be fixed/required by the specific SCEP server.

```
admin@(none) 05:08:11% config
Entering configuration mode private
[ok][2012-06-23 04:08:19]

[edit]
```

```
admin@(none) 04:08:19% set pki cert-info certificate-info my_ca_serv
Possible completions:
  common-name-x509  -
  country-x509      -
  digest-algo       - Digest Algorithm: default=md5?
  encrypt-algo      - Encryption Algorithm: default=des_cbc?
  locale-x509       -
  org-unit-x509     -
  organization-x509 -
  pkcs9-email-x509  -
  state-x509        -
```

The list above was displayed by entering Space-Tab after entering a name for the new set of certificate info.

The parameters that must be entered for your CA server must again be obtained from your System Administration or Security personnel. The common name and selection for digest and encryption algorithm will always be required. Other parameters may be required.

Here is an example:

```
admin@(none) 06:37:30> config
Entering configuration mode private
[ok][2012-06-23 06:37:32]

[edit]
admin@(none) 06:37:32% set pki cert-info certificate-info my_ca_serv organization-x509 “GE MDS LLC” org-unit-x509 Engineering common-name-x509 0010222000001020304112233445566 70 digest-algo sha256 encrypt-algo aes128_cbc
[ok][2012-06-23 06:38:34]

[edit]
admin@(none) 06:38:34%
```

Generating private key

To have the device generate a private key, the following request must be used:

- certmgr-generate-priv-key

The following example shows how to generate a public/private key-pair with identifier DEVKEY:

```
admin@(none) 21:54:47> request pki-generate-priv-key key-size 2048 key-identity DEVKEY
```

SCEP Certificate Requests

To load certificates via SCEP, the following requests must be used:

- **certmgr-scep-get-cacert** – To obtain CA certificate chain
- **certmgr-scep-get-clientcert** – To obtain device/client certificate

The first step is to acquire the CA published public certificate(s):

admin@(none) 00:27:14> request pki-scep-get-cacert cert-server-name ex_scep_serv ca-issuer-name ex_ca_serv

is-valid true

[ok][2012-06-23 00:27:47]

admin@(none) 00:27:47> show pki

```
KEY       KEY
IDENTITY  LENGTH  KEY DATE TIME
---------------------------------------
ex_key    2048    2012-06-20T10:46:59Z
ex_key_1  2048    2012-06-19T04:36:26Z

CACERT
IDENTITY
----------
ex_ca_server
ex_ca_server_ENC
ex_ca_server_SGN
```

Additional CA server files sent as part of the request and needed later are saved with the base name you selected for the CA server and an added extension. Some of the names that may be added are:

- **_ENC , encryption file**
- **_SGN , signing file**
- **_ISS , issuing file**
- **_INT , intermediate file**

The second step is to request a client cert from the CA server via the SCEP server.

admin@(none) 06:28:39> request pki-scep-get-clientcert cert-server-name ex_scep_serv cert-info-name my_ca_serv ca-issuer-name ex_ca_server cert-identification-name ex_c_cert cert-key-name ex_key_1 ca-challenge KoCZOBkaOH

is-valid true

[ok][2012-06-20 06:32:04]

admin@(none) 06:32:04> show pki

```
KEY       KEY
IDENTITY  LENGTH  KEY DATE TIME
---------------------------------------
ex_key    2048    2012-06-20T10:46:59Z
ex_key_1  2048    2012-06-19T04:36:26Z

CACERT
IDENTITY
----------
ex_ca_server
ex_ca_server_ENC
ex_ca_server_SGN

CERT
IDENTITY
----------
ex_c_cert
```

Certificate Renewal with SCEP

At some point, the dates on your certificate will need to be renewed due to time or security policy. A client certificate can be renewed using the existing certificate with the same key as originally used when it was generated. An alternative is to provide a new key and identify for the certificate that is to be renewed and rekeyed.

The same request is used to renew as for the original request with a slight change in parameters provided. For this request, the cert-key-name is always the key that will be used in the certificate that you identify with the cert-identification-name. The 'self' cert and optional 'self' key are respectively the existing certificate that will be renewed and the key that was originally used when it was created.

In the case we are going to use the same key in a renewed cert, it is not necessary to also call out this same key as the self key. Here is a renewal request formed accordingly:

```
admin@(none) 02:03:49% request pki-scep-get-clientcert cert-server-name ex_scep_serv
cert-info-name ex_cert_info ca-issuer-name ex_ca_server cert-identification-name tst3 cert-key-name
ex_key_2 cert-self-cert-name ex_c_cert_2

is-valid true
[ok][2012-06-24 02:05:19]

[edit]
admin@(none) 02:05:19% exit
admin@(none) 02:13:51> show pki

KEY        KEY
IDENTITY   LENGTH  KEY DATE TIME
----------------------------------------
ex_key     2048    2012-06-20T10:46:59Z
ex_key_1   2048    2012-06-19T04:36:26Z
ex_key_2   2048    2012-06-19T10:57:10Z

CACERT IDENTITY
------------------
ex_ca_server
ex_ca_server_ENC
ex_ca_server_SGN

CERT
IDENTITY
-------------
ex_c_cert_2
tst3
admin@(none) 02:05:19%
```

Here is an example of how to renew a cert with a new key and new cert name:

```
admin@(none) 05:16:58> request pki-scep-get-clientcert cert-server-name ex_scep_serv
cert-info-name ex_cert_info ca-issuer-name ex_ca_server cert-identification-name tst4 cert-key-name
ex_key_3 cert-self-cert-name tst3 cert-self-key-name ex_key_2

is-valid true
[ok][2012-06-24 05:17:32]
admin@(none) 05:17:32> show certmgr
```

```
KEY       KEY
IDENTITY  LENGTH  KEY DATE TIME
-------------------------------------
ex_key    2048    2012-06-20T10:46:59Z
ex_key_1  2048    2012-06-19T04:36:26Z
ex_key_2  2048    2012-06-19T10:57:10Z
ex_key_3  2048    2012-06-24T09:09:49Z

CACERT IDENTITY
------------------
pag_SGN
ex_ca_server
ex_ca_server_ENC
ex_ca_server_SGN

CERT
IDENTITY
-------------
ex_c_cert_2
tst3
tst4

[ok][2012-06-24 05:17:38]
admin@(none) 05:17:38>
```

Deleting security material

Obsolete security material in all categories can be deleted from the device with the 'delete' series of requests:

- **certmgr-delete-cacert**
- **certmgr-delete-cert**
- **certmgr-delete-firmware-certificate**
- **certmgr-delete-priv-key**

Here is an example of deleting the private key we have moved beyond when we re-keyed the client certificate in the last step:

```
admin@(none) 06:07:41% request pki-delete-priv-key key-identity ex_key_2
is-valid true
[ok][2012-06-24 06:07:55]
admin@(none) 06:07:55%
```

Firmware Certificate

The following example shows how to retrieve a certificate that can be used to verify a signed firmware package:

```
admin@(none) 06:07:41% request pki-get-firmware-certificate preconfigured-file-server {
configuration_name GE-FileServer-1 } filename certs/cert1.pem identity cert1
```

Monitoring

Certificate information can be viewed for the following items:

- **ca-cert-info**
- **client-cert-info**
- **firmware-cert-info**
- **priv-key-info**

Ensure the CLI is in operational mode. Follow the example below to view the state and statistics:

```
admin@(none) 01:03:45> show pki

               KEY
KEY IDENTITY   LENGTH  KEY DATE TIME
-------------------------------------------
test_priv_key  1024    2012-06-19T00:05:23Z

CACERT IDENTITY
------------------
test_ca_cert
test_ca_cert_INT
test_ca_cert_ISS

CERT IDENTITY
------------------
test_client_cert

FWCERT
IDENTITY  CERT HASH
-------------------------------------------------------------------------------
GE_Cert1  7bd5c7aa56f469614f5ee13daa0a0800b60d97fbccfcb85c9fc2af87656043d8

[ok][2012-06-19 01:03:49]
admin@(none) 01:03:49>
```

Event Logging

Understanding
An event is a notification that something meaningful occurred on the unit. Events contain information about the occurrence that may be useful for administrators. The event can be stored locally and/or transported to a remote server. Administrators can adjust which events are reported by the unit. The structure of the information about the event is described below (CEE).

NETCONF-notifications
The events generated by the unit are converted to NETCONF notifications. NETCONF clients can subscribe to the unit to receive those notifications.

Syslog
The events generated by the unit can be sent to remote syslog servers. The connection to the syslog server can be made secure using syslog over TLS.

Event Rules
All events can be configured to be logged to any combination of the following locations based on the event type:

- local: Store event in the local event log.
- netconf-notification: generate a NETCONF notification
- syslog: Forward events to a remote syslog server.

When logging to a syslog server, the following attributes can also be set:

- priority
- syslog-facility

Firmware Management

Understanding

The unit can have two firmware packages programmed into the device. The package that the device booted into is referred to as the *Active Firmware*. The other image is referred to as the *Inactive Firmware*.

To reprogram the device, the Active Firmware streams the new firmware package from the network and writes the package into the Inactive Firmware location in memory. To use the new firmware package, the user must reboot the device to the Inactive Firmware. Doing so will make the Inactive Firmware the Active Firmware and vice-versa.

Firmware packages released by the factory are digitally signed using a private key. The unit will not accept firmware packages that are unsigned nor will it accept firmware packages that fail to verify while using the public certificates loaded into the device. Therefore it is necessary to have the GE MDS public certificate loaded into the device to reprogram the firmware.

Users may add their own signatures to the firmware package using the GE MDS code signing tool.

NOTE: Any additional signatures added to a firmware package will require the corresponding public certificates to be loaded into the unit for firmware reprogramming to complete successfully. Similarly, any additional firmware-validation public certificates loaded into the unit require a firmware package to be signed with the corresponding private keys.

The request *reprogram-inactive-image* initiates the reprogramming sequence on the unit. The request will return immediately and the reprogramming sequence will continue in the background on the device. The reprogramming sequence can take several minutes. The status of the reprogramming sequence can be polled to know when reprogramming has completed.

```
admin@(none) 06:24:44> request system firmware reprogram-inactive-image preconfig-
ured-file-server { configuration_name GE-FileServer-1 } filename files/firmware.mpk

[ok][2012-06-21 06:25:26]
admin@(none) 06:25:26>
```

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state and statistics of the currently installed firmware packages:

```
admin@(none) 03:55:43> show system firmware versions
system firmware versions 1
version 1.0.1
active  true


CERTIFICATE
SIGNING
INDEX        CERTIFICATE SHA256
-------------------------------------------------------------------------------
1            3d9d795dcf374084de536986a29238ea7dc87104259619bc7aa4cfa3e2c64990
```

system firmware versions 2
version 1.0.0
active false

```
CERTIFICATE
SIGNING
INDEX        CERTIFICATE SHA256
-------------------------------------------------------------------------------
1            3d9d795dcf374084de536986a29238ea7dc87104259619bc7aa4cfa3e2c64990
```

Requesting an update

admin@(none) 03:55:43>request system firmware reprogram-inactive-image filename iwc-bkrc-1_0_0.mpk manual-file-server { tftp { address 192.168.1.10 } }

Retrieving Status on a Reprogramming Session

admin@(none) 03:55:43>show system firmware reprogramming-status
system firmware reprogramming-status state active
system firmware reprogramming-status detailed-message “Transferring file"
system firmware reprogramming-status size 36005116
system firmware reprogramming-status bytes-transferred 7455744
system firmware reprogramming-status percent-complete 20

admin@(none) 03:55:43>show system firmware reprogramming-status
system firmware reprogramming-status state complete
system firmware reprogramming-status detailed-message "Reprogrammed successfully"
system firmware reprogramming-status size 36005116
system firmware reprogramming-status bytes-transferred 35984896
system firmware reprogramming-status percent-complete 100

The command below provides a simple way to monitor percent complete.
(use control-C to abort)

admin@(none) 03:55:43>show system firmware reprogramming-status percent-complete | repeat 1
system firmware reprogramming-status percent-complete 25
system firmware reprogramming-status percent-complete 27
system firmware reprogramming-status percent-complete 28

Support Bundle

Understanding

The MCR incorporates a facility to generate a support package bundle that includes internal debugs, logs, etc. that can help GE MDS troubleshoot customer issues.

Configuring

The following example shows how to have MCR generate and transfer a support package bundle (named debug-2013-01-24.tgz) to a FTP server running on host (address 192.168.1.2) that is accessible from the MCR (e.g. a locally connected host or remote host accessible via cellular interface):

```
admin@(none) 22:14:57> request system support generate-support-package filename
debug-2013-01-24.tgz manual-file-server { ftp { address 192.168.1.2 username xyz password xyz } }
```

The MCR supports tftp, ftp, and sftp transfer protocols.

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state of support bundle transfer:

```
admin@(none) 22:17:18> show system support
system support support-transfer-status state Failed
system support support-transfer-status detailed-message “Transferring”
system support support-transfer-status size 0
system support support-transfer-status bytes-transferred 0
system support support-transfer-status percent-complete 0
[ok][2013-01-24 22:17:21]
```

4.0 TECHNICAL REFERENCE

4.1 Troubleshooting

All units must meet the basic requirements listed below for proper operation. Check these items first when troubleshooting a system problem:

- Adequate and stable primary power
- Secure connections (antennas, data and power)
- A clear transmission path between associated units
- An efficient, properly installed antenna system
- Proper configuration of unit settings
- Correct interface between the unit and other equipment

4.1.1 LED Status Indicators

The LEDs on the unit are visual indications of the status of the device. These indicators can provide useful information when troubleshooting. Refer to Table 8 for LED indications.

Figure 24. LED Status Indicators

Table 8. Description of LED Status Indicators

LED Name	LED State	Description
PWR (DC Power)	Off	No power to unit
	Solid Green	Unit is powered, no problems detected
	Solid Amber	Initializing-bootup
	Fast Blink/Red (1x/sec.)	Alarm indication
ETH (Ethernet)	Off	No Ethernet link to network
	Solid Green	Ethernet link present
	Blinking Green	Ethernet traffic in/out
COM (Serial Comm. Port)	Off	No serial connection, or idle
	Blinking Green	Serial traffic in/out
NIC1 (Cell)	Off	No cellular connection
	Solid Green	Cell Connection w/RSSI >-80 dBm
	Solid Amber	Cell Connection w/RSSI between -90 & -80 dBm
	Solid Red	Cell connection w/RSSI<-90 dBm
NIC2 (WiFi)	Off	Interface disabled
Access Point Mode	Solid Green	Operating as AP and at least one client connection
	Solid Red	Operating as an AP and no client connection
Station Mode	Off	No connection
	Solid Green	Connected with ”good” signal (RSSI stronger than -48 dBm)
	Solid Amber	Connected with “medium” signal (RSSI between -49 & -69 dBm)
	Solid Red	Connected with ”weak” signal (RSSI less than -70 dBm)

NOTE: In addition to the LEDs above, the Ethernet connector has two embedded LEDs. A yellow indicates a link at 100 Mbps operation. A flashing green indicates Ethernet data traffic.

4.2 Specifications

GENERAL
Input Power: 10 to 60 Vdc, 15 W maximum
Temperature: -40°C to +70°C
Housing: Die-cast Aluminum

PHYSICAL
Size: 6.5" long (16.51 cm), 4.625" wide (11.75 cm), 1.5" High (3.81 cm)

Weight: 2 lbs (without mounting hardware)

ENVIRONMENTAL
Ethernet Port(s): RJ-45 10/100
Serial Port(s): RJ-45, supporting RS-232/RS-485
LAN Protocols: 802.3 (Ethernet) 802.1D (Spanning Tree) TCP/IP, DHCP, ICMP, IGMP, FTP, TFTP, SFTP, UDP
Networking: DHCP, Port Forwarding, NAT
Configuration: Serial console, SSH, Configuration files
Security: Encryption, Password access, Radius

4.3 Agency/Regulatory Approvals

FCC:

- WiFi – M4Y-ZCN722MV1,
- Cell – PKRNVWE362

IC - Industry:

- WiFi – 3195A-ZCN722MV1
- Cell -3229B-E362

Specifications subject to change without notice or obligation.

4.4 Glossary of Terms & Abbreviations

If you are new to wireless communications systems, some of the terms used in this guide may be unfamiliar. The following glossary explains many of these terms and will prove helpful in understanding the operation of the unit.

Antenna System Gain: A figure, normally expressed in dB, representing the power increase resulting from the use of a gain-type antenna. System losses (from the feedline and coaxial connectors, for example) are subtracted from this figure to calculate the total antenna system gain.

Bit: The smallest unit of digital data, often represented by a one or a zero. Eight bits (plus start, stop, and parity bits) usually comprise a byte.

Bits-per-second: See *BPS*.

BPS (Bits-per-second): A measure of the information transfer rate of digital data across a communication channel.

Bridging: (see *Ethernet Bridging*)

Byte: A string of digital data usually made up of eight data bits and start, stop and parity bits.

CLI: Command Line Interface. A method of user control where commands are entered as character strings to set configuration and operating parameters.

CTS: Clear to Send

Decibel (dB): A measure computed from the ratio between two signal levels. Frequently used to express the gain (or loss) of a system.

Data Circuit-terminating Equipment: See *DCE*.

Data Communications Equipment: See *DCE*.

Data Terminal Equipment: See *DTE*.

dBi: Decibels referenced to an "ideal" isotropic radiator in free space, frequently used to express antenna gain.

dBm: Decibels referenced to one milliwatt. An absolute unit used to measure signal power, as in transmitter power output, or received signal strength.

DCE (Data Circuit-terminating Equipment) (or Data Communications Equipment): In data communications terminology, this is the "modem" side of a computer-to-modem connection. The unit described in this manual is hardwired as a DCE device.

DTE (Data Terminal Equipment): A device that provides data in the form of digital signals at its output. DTE connects to the DCE device.

ETH: Ethernet

Fade Margin: The greatest tolerable reduction in average received signal strength that will be anticipated under most conditions. It provides an allowance for reduced signal strength due to multipath, slight antenna movement or changing atmospheric losses. A fade margin of 20 to 30 dB is usually sufficient in most systems.

FPGA: Field Programmable Gate Array

Frame: A segment of data that adheres to a specific data protocol and contains definite start and end points. It provides a method of synchronizing transmissions.

Hardware Flow Control: A feature used to prevent data buffer overruns when the unit is handling high-speed data from an RTU or PLC. When the buffer approaches overflow, the unit drops the clear-to-send (CTS) line, which instructs the RTU or PLC to delay further transmission until CTS again returns to the high state.

Host Computer: The computer installed at the master unit, which controls the collection of data from one or more remote sites.

IP: Internet Protocol

LAN: Local Area Network

LED: Light Emitting Diode

mA: Milliamperes

MAC: Media Access Control

Poll: A request for data issued from the host computer (or master PLC) to a Remote unit.

PLC (Programmable Logic Controller): A dedicated microprocessor configured for a specific application with discrete inputs and outputs. It can serve as a host or as an RTU.

PPM: Parts per Million

Programmable Logic Controller: See *PLC*.

Remote Terminal Unit: See *RTU*.

RTS: Request-to-send

RTU: Remote Terminal Unit. A data collection device installed at a Remote unit site.

RX: Abbreviation for “Receive.”

Signal-to-Noise Ratio: *See SNR.*

SCADA (Supervisory Control And Data Acquisition): An overall term for the functions commonly provided through an MAS radio system.

SCEP: Simple Certificate Enrollment Protocol. A scalable protocol for networks based on digital certificates, which can be requested by users without the need for assistance or manual intervention from a system administrator.

SNR (Signal-to-Noise ratio): A measure of how well the signal is being received at a radio relative to noise on the channel.

SSH: Secure Shell protocol for a network that allows users to open a window on a local PC and connect to a remote PC as if they were present at the remote.

SSID (Service Set Identifier): A name that identifies a particular 802.11wireless LAN.

Supervisory Control And Data Acquisition: See *SCADA*.

Telnet: A terminal emulation protocol that enables an Internet user to communicate with a Remote device for management activities as if it were locally connected to a PC.

TX: Abbreviation for “Transmit.”

WAN: Wide Area Network

5.0 APPENDIX A – DATA CONFIGURATION TREE

Initial Firmware version

The following is a hierarchical view of the data configuration tree for the unit. It is a composition of all YANG files used by the unit.

```
+--rw file-servers [configuration-name]
  |  +--rw configuration-name    string
  |  +--rw (protocol)
  |     +--:(tftp)
  |     |  +--rw tftp
  |     |     +--rw address       string
  |     |     +--rw block-size?   unit32
  |     |     +--rw port?         uint16
  |     |     +--rw timeout?      uint32
  |     +--:(sftp)
  |     |  +--rw sftp
  |     |     +--rw address     string
  |     |     +--rw username    string
  |     |     +--rw password    string
  |     |     +--rw port?       uint16
  |     |     +--rw timeout?    uint32
  |     +--:(ftp)
  |     |  +--rw ftp
  |     |     +--rw address        string
  |     |     +--rw username?      string
  |     |     +--rw password?      string
  |     |     +--rw control-port?  uint16
  |     |     +--rw data-port?     uint16
  |     |     +--rw timeout?       uint32
  |     +--:(http)
  |        +--rw http
  |           +--rw address?   string
  |           +--rw port?      uint16
  |           +--rw timeout?   uint32
  +--rw interfaces
  |  +--rw interface [name]
  |  |  +--rw name                        string
  |  |  +--rw description?                string
  |  |  +--rw enabled?                    boolean
  |  |  +--ro oper-status?                enumeration
  |  |  +--ro last-change?                yang:date-and-time
  |  |  +--ro if-index?                   int32
  |  |  +--rw link-up-down-trap-enable?   enumeration
  |  |  +--ro phys-address?               yang:phys-address
  |  |  +--ro higher-layer-if*            interface-ref
  |  |  +--ro lower-layer-if*             interface-ref
  |  |  +--ro speed?                      yang:gauge64
  |  |  +--ro statistics
  |  |  |  +--ro discontinuity-time?   yang:date-and-time
  |  |  |  +--ro in-octets?            yang:counter64
  |  |  |  +--ro in-unicast-pkts?      yang:counter64
```

```
| | | +--ro in-broadcast-pkts?    yang:counter64
| | | +--ro in-multicast-pkts?    yang:counter64
| | | +--ro in-discards?          yang:counter32
| | | +--ro in-errors?            yang:counter32
| | | +--ro in-unknown-protos?    yang:counter32
| | | +--ro out-octets?           yang:counter64
| | | +--ro out-unicast-pkts?     yang:counter64
| | | +--ro out-broadcast-pkts?   yang:counter64
| | | +--ro out-multicast-pkts?   yang:counter64
| | | +--ro out-discards?         yang:counter32
| | | +--ro out-errors?           yang:counter32
| | +--rw ip:ipv4?
| | | +--rw ip:enabled?             boolean
| | | +--rw ip:forwarding?          boolean
| | | +--rw ip:mtu?                 uint16
| | | +--rw ip:address [ip]
| | | | +--rw ip:ip             inet:ipv4-address-no-zone
| | | | +--rw (subnet)
| | | |    +--:(prefix-length)
| | | |    | +--rw ip:prefix-length?   uint8
| | | |    +--:(netmask)
| | | |       +--rw ip:netmask?        yang:dotted-quad
| | | +--rw ip:neighbor [ip]
| | | | +--rw ip:ip             inet:ipv4-address-no-zone
| | | | +--rw ip:phys-address?   yang:phys-address
| | | +--rw mdsif:dhcp?
| | | | +--rw mdsif:client-identifier?   string
| | | | +--rw mdsif:retry-interval?      uint16
| | | +--ro mdsif:current-address [ip]
| | |    +--ro mdsif:ip             inet:ipv4-address-no-zone
| | |    +--ro mdsif:prefix-length?   uint8
| | +--rw ip:ipv6?
| | | +--rw ip:enabled?                boolean
| | | +--rw ip:forwarding?             boolean
| | | +--rw ip:mtu?                    uint32
| | | +--rw ip:address [ip]
| | | | +--rw ip:ip             inet:ipv6-address-no-zone
| | | | +--rw ip:prefix-length    uint8
| | | +--rw ip:neighbor [ip]
| | | | +--rw ip:ip             inet:ipv6-address-no-zone
| | | | +--rw ip:phys-address?   yang:phys-address
| | | +--rw ip:dup-addr-detect-transmits?   uint32
| | | +--rw ip:autoconf
| | | | +--rw ip:create-global-addresses?       boolean
| | | | +--rw ip:create-temporary-addresses?    boolean
| | | | +--rw ip:temporary-valid-lifetime?      uint32
| | | | +--rw ip:temporary-preferred-lifetime?   uint32
| | | +--ro mdsif:current-address [ip]
| | |    +--ro mdsif:ip             inet:ipv6-address-no-zone
| | |    +--ro mdsif:prefix-length?   uint8
| | +--rw mdsif:eth-phy-rate?          bits
| | +--ro mdsif:eth-phy-status?        enumeration
| | +--rw mdsif:virtual-type?          identityref
| | +--rw mdsif:physical-interface?    leafref
| | +--ro mdsif:system-device?         string
```

```
| | +--ro mdsif:neighbors
| | | +--ro mdsif:ip?           inet:ip-address-no-zone
| | | +--ro mdsif:phys-address?   yang:phys-address
| | | +--ro mdsif:state?         enumeration
| | +--rw mds_wifi:wifi-config?
| | | +--rw mds_wifi:mode             enumeration
| | | +--rw mds_wifi:tx-power?        uint32
| | | +--rw mds_wifi:station-config?
| | | | +--rw mds_wifi:ap [ssid]
| | | |   +--rw mds_wifi:ssid          string
| | | |   +--rw mds_wifi:enabled?      boolean
| | | |   +--rw mds_wifi:privacy-mode?   enumeration
| | | |   +--rw mds_wifi:psk-config
| | | |   | +--rw mds_wifi:encryption?   enumeration
| | | |   | +--rw mds_wifi:key-mgmt?     enumeration
| | | |   | +--rw mds_wifi:psk?          string
| | | |   +--rw mds_wifi:eap-config
| | | |   | +--rw mds_wifi:encryption?   enumeration
| | | |   | +--rw mds_wifi:key-mgmt?     enumeration
| | | |   | +--rw mds_wifi:eap-method?   enumeration
| | | |   +--rw mds_wifi:pki?
| | | |     +--rw mds_wifi:cert-type     enumeration
| | | |     +--rw mds_wifi:cert-id       string
| | | |     +--rw mds_wifi:key-id        string
| | | |     +--rw mds_wifi:ca-cert-id    string
| | | +--rw mds_wifi:ap-config?
| | |   +--rw mds_wifi:ap [ssid]
| | |   | +--rw mds_wifi:ssid              string
| | |   | +--rw mds_wifi:broadcast-ssid?   boolean
| | |   | +--rw mds_wifi:station-max?      uint32
| | |   | +--rw mds_wifi:station-timeout?  uint32
| | |   | +--rw mds_wifi:beacon-interval?  uint32
| | |   | +--rw mds_wifi:privacy-mode?     enumeration
| | |   | +--rw mds_wifi:psk-config
| | |   | | +--rw mds_wifi:encryption?   enumeration
| | |   | | +--rw mds_wifi:key-mgmt?     enumeration
| | |   | | +--rw mds_wifi:psk?          string
| | |   | +--rw mds_wifi:eap-config
| | |   | | +--rw mds_wifi:encryption?   enumeration
| | |   | | +--rw mds_wifi:key-mgmt?     enumeration
| | |   | | +--rw mds_wifi:eap-method?   enumeration
| | |   | +--rw mds_wifi:radius-server?    leafref
| | |   | +--rw mds_vlan:vlan-mode?        enumeration
| | |   | +--rw mds_vlan:vlans*            if:interface-ref
| | |   | +--rw mds_vlan:vlan?             if:interface-ref
| | |   +--rw mds_wifi:channel?          uint32
| | |   +--rw mds_wifi:operation-mode?   enumeration
| | |   +--rw mds_wifi:dtim-period?      uint32
| | |   +--rw mds_wifi:rts-threshold?    uint32
| | |   +--rw mds_wifi:fragm-threshold?  uint32
| | +--ro mds_wifi:wifi-status
| | | +--ro mds_wifi:serial-number?   display-string
| | | +--ro mds_wifi:mode?            display-string
| | | +--ro mds_wifi:tx-power?        uint8
| | | +--ro mds_wifi:channel?         uint8
```

```
| | | +--ro mds_wifi:ap-status
| | | | +--ro mds_wifi:ap [ssid]
| | | |    +--ro mds_wifi:ssid      ssid
| | | |    +--ro mds_wifi:client [mac]
| | | |       +--ro mds_wifi:mac             string
| | | |       +--ro mds_wifi:rssi?           int8
| | | |       +--ro mds_wifi:authenticated?   boolean
| | | |       +--ro mds_wifi:authorized?      boolean
| | | |       +--ro mds_wifi:inactive?        uint32
| | | |       +--ro mds_wifi:rxbytes?         uint32
| | | |       +--ro mds_wifi:rxpackets?       uint32
| | | |       +--ro mds_wifi:txbitrate?       uint16
| | | |       +--ro mds_wifi:txbytes?         uint32
| | | |       +--ro mds_wifi:txpackets?       uint32
| | | |       +--ro mds_wifi:txfailed?        uint32
| | | |       +--ro mds_wifi:txretries?       uint32
| | | +--ro mds_wifi:station-status
| | |    +--ro mds_wifi:ssid?           ssid
| | |    +--ro mds_wifi:bssid?          string
| | |    +--ro mds_wifi:rssi?           int8
| | |    +--ro mds_wifi:authenticated?   boolean
| | |    +--ro mds_wifi:authorized?      boolean
| | |    +--ro mds_wifi:inactive?        uint32
| | |    +--ro mds_wifi:rxbytes?         uint32
| | |    +--ro mds_wifi:rxpackets?       uint32
| | |    +--ro mds_wifi:txbitrate?       uint16
| | |    +--ro mds_wifi:txbytes?         uint32
| | |    +--ro mds_wifi:txpackets?       uint32
| | |    +--ro mds_wifi:txfailed?        uint32
| | |    +--ro mds_wifi:txretries?       uint32
| | +--rw mds_vlan:vlan-config
| | | +--rw mds_vlan:vlan-id?       vlan-id
| | | +--rw mds_vlan:native-vlan?   boolean
| | +--rw mds_vlan:vlan-mode?          enumeration
| | +--rw mds_vlan:vlans*              if:interface-ref
| | +--rw mds_vlan:vlan?               if:interface-ref
| | +--rw mds_bridge:bridgeStatus
| | | +--rw mds_bridge:stp
| | |    +--ro mds_bridge:port [interface]
| | |       +--ro mds_bridge:interface          if:interface-ref
| | |       +--ro mds_bridge:number?            uint32
| | |       +--ro mds_bridge:priority?          uint8
| | |       +--ro mds_bridge:state?             enumeration
| | |       +--ro mds_bridge:path-cost?         uint32
| | |       +--ro mds_bridge:designated-root?   string
| | |       +--ro mds_bridge:designated-cost?   uint32
| | |       +--ro mds_bridge:designated-bridge?   string
| | |       +--ro mds_bridge:designated-port?   uint32
| | +--rw mds_bridge:bridge-settings
| | | +--rw mds_bridge:members
| | | | +--rw mds_bridge:port [interface]
| | | | | +--rw mds_bridge:interface       if:interface-ref
| | | | | +--rw mds_bridge:port-priority?   uint32
| | | | | +--rw mds_bridge:port-path-cost?   uint32
| | | | +--rw mds_bridge:wifi-ap [ssid]
```

```
| | | | | +--rw mds_bridge:ssid              leafref
| | | | | +--rw mds_bridge:port-priority?    uint32
| | | | | +--rw mds_bridge:port-path-cost?   uint32
| | | | +--rw mds_bridge:wifi-station
| | | |    +--rw mds_bridge:interface?       if:interface-ref
| | | |    +--rw mds_bridge:port-priority?    uint32
| | | |    +--rw mds_bridge:port-path-cost?   uint32
| | | +--rw mds_bridge:stp-mode?          enumeration
| | | +--rw mds_bridge:ageing-time?       uint32
| | | +--rw mds_bridge:max-age?           uint32
| | | +--rw mds_bridge:hello-time?        uint32
| | | +--rw mds_bridge:forward-delay?     uint32
| | | +--rw mds_bridge:bridge-priority?   uint32
| | +--rw mds-cell:cell-config
| | | +--rw mds-cell:apn?               string
| | | +--rw mds-cell:keep-alive?
| | | | +--rw mds-cell:address              inet:host
| | | | +--rw mds-cell:interval?            uint8
| | | | +--rw mds-cell:recovery-on-timeout?   boolean
| | | | +--rw mds-cell:max-num-retries?       uint8
| | | +--rw mds-cell:service-recovery
| | |    +--rw mds-cell:general-recovery-interval?   uint16
| | |    +--rw mds-cell:lte-recovery?              boolean
| | |    +--rw mds-cell:lte-recovery-interval?       uint16
| | +--ro mds-cell:cell-status
| | | +--ro mds-cell:imsi?              display-string
| | | +--ro mds-cell:imei?              display-string
| | | +--ro mds-cell:iccid?             display-string
| | | +--ro mds-cell:mdn?               display-string
| | | +--ro mds-cell:apn?               display-string
| | | +--ro mds-cell:app-sw-version?    display-string
| | | +--ro mds-cell:modem-sw-version?  display-string
| | | +--ro mds-cell:sim-state?         display-string
| | | +--ro mds-cell:modem-state?       enumeration
| | | +--ro mds-cell:roaming-state?     enumeration
| | | +--ro mds-cell:service-state?     enumeration
| | | +--ro mds-cell:rssi?              int8
| | +--rw mds_nx:nx-config?
| | | +--rw mds_nx:owner_msg?      string
| | | +--rw mds_nx:lna_enable?     boolean
| | | +--rw mds_nx:opmode?         enumeration
| | | +--rw mds_nx:modem_mode      enumeration
| | | +--rw mds_nx:device_mode     enumeration
| | | +--rw mds_nx:network_name    string
| | | +--rw mds_nx:dwell_time?     uint16
| | | +--rw mds_nx:sync_time?      uint16
| | | +--rw mds_nx:static_nic_id?  uint16
| | +--ro mds_nx:nx-status
| | | +--ro mds_nx:sernum?         uint32
| | | +--ro mds_nx:fwrev?          string
| | | +--ro mds_nx:hwid?           uint32
| | | +--ro mds_nx:hwrev?          uint32
| | | +--ro mds_nx:xcvr_temp?      int32
| | | +--ro mds_nx:ethif_stats
| | | | +--ro mds_nx:rx_dropped?         uint32
```

```
| | | |  +--ro mds_nx:tx_dropped?          uint32
| | | |  +--ro mds_nx:rx_unavailable?      uint32
| | | |  +--ro mds_nx:tx_unavailable?      uint32
| | | |  +--ro mds_nx:resource_failures?   uint32
| | | |  +--ro mds_nx:init_failures?       uint32
| | | |  +--ro mds_nx:rx_bad_mtu?          uint32
| | | |  +--ro mds_nx:tx_bad_mtu?          uint32
| | |  +--ro mds_nx:nicsvcs_stats
| | |     +--ro mds_nx:nic_tx_dropped?    uint32
| | |     +--ro mds_nx:data_tx_dropped?   uint32
| | |     +--ro mds_nx:mgmt_rx_dropped?   uint32
| | |     +--ro mds_nx:data_rx_dropped?   uint32
| | |     +--ro mds_nx:eth_lb_cnt?        uint32
| | |     +--ro mds_nx:vcp_lb_cnt?        uint32
| | |     +--ro mds_nx:mgmt_set_cnt?      uint32
| | |     +--ro mds_nx:mgmt_get_cnt?      uint32
| |  +--rw fire:filter
| | |  +--rw fire:input?    leafref
| | |  +--rw fire:output?   leafref
| |  +--rw fire:nat
| |     +--rw fire:source?       leafref
| |     +--rw fire:destination?  leafref
|  +--rw mdsif:physical-interface [name]
|     +--rw mdsif:name          string
|     +--rw mdsif:type          identityref
|     +--rw mdsif:system-name    string
+--rw logging
|  +--rw event-rules [name]
|  |  +--rw name                 string
|  |  +--rw description?         string
|  |  +--rw local?               boolean
|  |  +--rw priority?            priority-enumeration
|  |  +--rw syslog-facility?     enumeration
|  |  +--rw syslog?              boolean
|  |  +--rw snmp-notification?   boolean
|  |  +--rw snmp-notify-name?    leafref
|  |  +--rw netconf-notification?  boolean
|  |  +--rw alarm?               boolean
|  |  +--rw alarm-outputs*       leafref
|  +--rw syslog
|  |  +--rw server [name]
|  |     +--rw name          string
|  |     +--rw ip            inet:host
|  |     +--rw port?         inet:port-number
|  |     +--rw version?      enumeration
|  |     +--rw protocol?     enumeration
|  |     +--rw tls-options
|  |        +--rw tls-ca-certificate?      string
|  |        +--rw tls-client-certificate?  string
|  |        +--rw tls-client-key?          string
|  +--rw debug
|  |  +--rw verbose?     boolean
|  |  +--rw components*  string
|  +--rw alarm-output [name]
|  |  +--rw name             string
```

```
| | +--rw signal-period?     uint32
| | +--rw signal-duration?   uint32
| +--ro event-log [id]
| | +--ro id           int64
| | +--ro time-stamp?   yang:date-and-time
| | +--ro priority?     priority-enumeration
| | +--ro event-type?   string
| | +--ro status?       string
| | +--ro message?      string
| +--ro current-alarms [name]
|   +--ro name      string
|   +--ro events*   string
+--rw pki
| +--rw certificate-servers
| | +--rw certificate-server [cert-server-identity]
| |   +--rw cert-server-identity            string
| |   +--rw server-type?                    cert-mgmt-type
| |   +--rw certmgr-servers:server-setting
| |     +--rw certmgr-servers:uri?          inet:uri
| |     +--rw certmgr-servers:retry-count?    uint16
| |     +--rw certmgr-servers:poll-interval?  uint16
| |     +--rw certmgr-servers:digest-algo?    cm:certmgr-digest-algo
| |     +--rw certmgr-servers:encrypt-algo?   cm:certmgr-enc-algo
| +--rw cert-info
| | +--rw certificate-info [certificate-info-identity]
| |   +--rw certificate-info-identity   string
| |   +--rw country-x509?               string
| |   +--rw state-x509?                 string
| |   +--rw locale-x509?                string
| |   +--rw organization-x509?          string
| |   +--rw org-unit-x509?              string
| |   +--rw common-name-x509            string
| |   +--rw pkcs9-email-x509?           string
| +--rw ca-servers
| | +--rw ca-server [ca-issuer-identity]
| |   +--rw ca-issuer-identity   string
| |   +--rw ca-identity?         string
| |   +--rw ca-fingerprint?      string
| +--ro private-keys [key-identity]
| | +--ro key-identity    string
| | +--ro key-length?     uint16
| | +--ro key-date-time?  string
| +--ro ca-certs [cacert-identity]
| | +--ro cacert-identity   string
| +--ro cacert-names [cacert-base-name]
| | +--ro cacert-base-name   string
| +--ro client-certs [cert-identity]
| | +--ro cert-identity   string
| +--ro firmware-certs
| | +--ro fwcert-identity?  string
| | +--ro cert-hash?        string
| +--ro scep-status
|   +--ro last-status?    int32
|   +--ro poll-count?     int32
|   +--ro last-state?     string
```

```
|    +--ro req-fp-md5?      string
|    +--ro req-fp-sha1?     string
|    +--ro req-fp-sha256?   string
|    +--ro req-fp-sha512?   string
+--rw system
| +--rw contact?                    string
| +--rw name?                       string
| +--rw location?                   string
| +--ro platform
| | +--ro os-name?      string
| | +--ro os-release?   string
| | +--ro os-version?   string
| | +--ro machine?      string
| | +--ro nodename?     string
| +--rw clock
| | +--ro current-datetime?      yang:date-and-time
| | +--ro boot-datetime?         yang:date-and-time
| | +--rw (timezone)?
| | | +--:(timezone-location)
| | | | +--rw timezone-location?     ianatz:iana-timezone
| | | +--:(timezone-utc-offset)
| | |    +--rw timezone-utc-offset?   int16
| | +--rw mdssys:set
| +--rw ntp
| | +--rw use-ntp?      boolean
| | +--rw ntp-server [address]
| |    +--rw association-type?   enumeration
| |    +--rw address             inet:host
| |    +--rw enabled?            boolean
| |    +--rw iburst?             boolean
| |    +--rw prefer?             boolean
| +--rw dns
| | +--rw search*    inet:host
| | +--rw server*    inet:ip-address
| | +--rw options
| |    +--rw timeout?    uint8
| |    +--rw attempts?   uint8
| +--rw radius
| | +--rw server [address]
| | | +--rw address                inet:host
| | | +--rw authentication-port?   inet:port-number
| | | +--rw shared-secret?         string
| | | +--rw authentication-type?   identityref
| | +--rw options
| |    +--rw timeout?    uint8
| |    +--rw attempts?   uint8
| +--rw authentication
| | +--rw user-authentication-order*   identityref
| | +--rw user [name]
| |    +--rw name       string
| |    +--rw password?   crypt-hash
| |    +--rw ssh-key [name]
| |       +--rw name         string
| |       +--rw algorithm?   string
| |       +--rw key-data?    binary
```

```
| +--ro mdssys:serial-number-core?       uint32
| +--ro mdssys:serial-number-platform?   uint32
| +--ro mdssys:product-configuration?    string
| +--ro mdssys:guid?                     string
| +--rw mdssys:pre-login-banner?         string
| +--rw mdssys:authentication
| | +--rw mdssys:max-login-attempts?         uint32
| | +--rw mdssys:failed-login-lockout-time?  uint32
| | +--rw mdssys:user-authentication-order*  identityref
| | +--rw mdssys:password-options
| |    +--rw mdssys:minimum-length?            uint16
| |    +--rw mdssys:minimum-lower-case-letters? uint16
| |    +--rw mdssys:minimum-capital-letters?    uint16
| |    +--rw mdssys:minimum-numeric?           uint16
| |    +--rw mdssys:minimum-non-alpha-numeric?  uint16
| +--rw mdssys:mds-radius
| | +--rw mdssys:servers [name]
| | | +--rw mdssys:name                  string
| | | +--rw mdssys:address               inet:host
| | | +--rw mdssys:authentication-port?  inet:port-number
| | | +--rw mdssys:shared-secret         string
| | | +--rw mdssys:user-authentication-type?  identityref
| | +--rw mdssys:options
| |    +--rw mdssys:timeout?   uint8
| |    +--rw mdssys:attempts?  uint8
| +--rw mdssys:firmware
| | +--ro mdssys:versions [location]
| | | +--ro mdssys:location     uint8
| | | +--ro mdssys:version?     string
| | | +--ro mdssys:active?      boolean
| | | +--ro mdssys:signatures [certificate-signing-index]
| | |    +--ro mdssys:certificate-signing-index   uint8
| | |    +--ro mdssys:certificate-sha256?         string
| | +--ro mdssys:reprogramming-status
| |    +--ro mdssys:state?            enumeration
| |    +--ro mdssys:detailed-message? string
| |    +--ro mdssys:size?             uint32
| |    +--ro mdssys:bytes-transfered? uint32
| |    +--ro mdssys:percent-complete? uint32
| +--rw mdssys:geographical-location
| | +--rw mdssys:latitude?             decimal64
| | +--rw mdssys:longitude?            decimal64
| | +--rw mdssys:altitude?             decimal64
| | +--ro mdssys:current-gps-location
| |    +--ro mdssys:latitude?     decimal64
| |    +--ro mdssys:longitude?    decimal64
| |    +--ro mdssys:altitude?     decimal64
| |    +--ro mdssys:fix-quality?  enumeration
| |    +--ro mdssys:satellites [prn]
| |       +--ro mdssys:prn        uint8
| |       +--ro mdssys:snr?       uint8
| |       +--ro mdssys:azimuth?   uint16
| |       +--ro mdssys:elevation? uint8
| |       +--ro mdssys:used?      boolean
| +--rw mdssys:support
```

```
| | +--ro mdssys:support-transfer-status
| |    +--ro mdssys:state?            enumeration
| |    +--ro mdssys:detailed-message?   string
| |    +--ro mdssys:size?             uint32
| |    +--ro mdssys:bytes-transfered?   uint32
| |    +--ro mdssys:percent-complete?   uint32
| +--rw mdssys:power
| +--rw mdssys:configuration-files
| +--rw mdssys:recovery
| | +--ro mdssys:snapshots
| | | +--ro mdssys:identifier     string
| | | +--ro mdssys:description?   string
| | | +--ro mdssys:date?          string
| | | +--ro mdssys:version?       string
| | | +--ro mdssys:hash?          string
| | +--rw mdssys:one-time-passwords
| |    +--ro mdssys:passwords
| |       +--ro mdssys:identifier      uint64
| |       +--ro mdssys:function?       otp-function-type
| |       +--ro mdssys:status?         status_type
| |       +--ro mdssys:date-created?   string
| |       +--ro mdssys:date-revoked?   string
| |       +--ro mdssys:user?           string
| +--ro mdssys:uptime
|    +--ro mdssys:seconds?   uint32
|    +--ro mdssys:text?      string
+--ro processes [job_id]
| +--ro job_id          int32
| +--ro pid?            int32
| +--ro filename?       string
| +--ro args?           string
| +--ro env?            string
| +--ro cpu_time_sys?    int64
| +--ro cpu_time_user?   int64
| +--ro memory_usage?    uint64
+--rw routing
| +--rw static-routes
| | +--rw ipv4
| | | +--rw route [id]
| | |    +--rw id                  uint32
| | |    +--rw description?        string
| | |    +--rw outgoing-interface?   if:interface-ref
| | |    +--rw dest-prefix         inet:ipv4-prefix
| | |    +--rw next-hop?           inet:ipv4-address
| | +--rw ipv6
| |    +--rw route [id]
| |       +--rw id                  uint32
| |       +--rw description?        string
| |       +--rw outgoing-interface?   if:interface-ref
| |       +--rw dest-prefix         inet:ipv6-prefix
| |       +--rw next-hop?           inet:ipv6-address
| +--ro routes
|    +--ro dest-prefix?         inet:ip-prefix
|    +--ro next-hop?            inet:ip-address
|    +--ro outgoing-interface?   if:interface-ref
```

```
|    +--ro source?              enumeration
+--rw services
| +--ro services-status [name]
| | +--ro name      string
| | +--ro status?   enumeration
| +--rw dhcp:dhcp
| | +--ro dhcp:leases [ip]
| | | +--ro dhcp:ip              inet:ip-address
| | | +--ro dhcp:starts?         yang:date-and-time
| | | +--ro dhcp:ends?           yang:date-and-time
| | | +--ro dhcp:binding-state?   enumeration
| | | +--ro dhcp:client-mac?      yang:mac-address
| | | +--ro dhcp:hostname?        string
| | +--rw dhcp:enabled?            boolean
| | +--rw dhcp:default-lease-time?   uint32
| | +--rw dhcp:min-lease-time?       uint32
| | +--rw dhcp:max-lease-time?       uint32
| | +--rw dhcp:v4subnet [subnet-mask]
| | | +--rw dhcp:subnet-mask           inet:ipv4-prefix
| | | +--rw dhcp:range-start           inet:ipv4-address
| | | +--rw dhcp:range-end             inet:ipv4-address
| | | +--rw dhcp:broadcast-address?     inet:ipv4-address
| | | +--rw dhcp:router?                inet:ipv4-address
| | | +--rw dhcp:domain-name-servers*    inet:ipv4-address
| | | +--rw dhcp:domain-name?           inet:domain-name
| | | +--rw dhcp:ntp-servers*           inet:host
| | | +--rw dhcp:netbios-name-servers*   inet:host
| | +--rw dhcp:v6subnet [subnet-mask]
| |    +--rw dhcp:subnet-mask    inet:ipv6-prefix
| |    +--rw dhcp:range-start    inet:ipv6-address
| |    +--rw dhcp:range-end      inet:ipv6-address
| +--rw iperf:iperf
| | +--rw iperf:enabled?   boolean
| +--rw serial:serial
| | +--rw serial:ports [name]
| | | +--rw serial:name              string
| | | +--rw serial:line-mode?        enumeration
| | | +--rw serial:baud-rate?        enumeration
| | | +--rw serial:byte-format?      enumeration
| | | +--rw serial:hw-flow-control?   boolean
| | | +--rw serial:vmin?             uint32
| | | +--rw serial:vtime?            uint16
| | | +--rw serial:capability?       bits
| | +--rw serial:console
| | | +--rw serial:serial-ports*   leafref
| | +--rw serial:terminal-server
| |    +--rw serial:server [serial-port]
| |       +--rw serial:serial-port    leafref
| |       +--rw serial:description?   string
| |       +--rw serial:enabled?       boolean
| |       +--rw serial:mode
| |       | +--rw (tcp-or-udp)?
| |       |    +--:(tcp)
| |       |    | +--rw serial:tcp-server?
| |       |    | | +--rw serial:port?          inet:port-number
```

```
| |      |    | | +--rw serial:idle-timeout?   uint32
| |      |    | +--rw serial:tcp-client?
| |      |    |    +--rw serial:remote
| |      |    |    | +--rw serial:address    inet:ip-address
| |      |    |    | +--rw serial:port?      inet:port-number
| |      |    |    +--rw serial:idle-timeout?   uint32
| |      |    +--:(modbus-tcp)
| |      |    | +--rw serial:modbus-tcp?
| |      |    |    +--rw serial:mode          enumeration
| |      |    |    +--rw serial:port?         inet:port-number
| |      |    |    +--rw serial:idle-timeout?   uint32
| |      |    +--:(udp)
| |      |      +--rw serial:udp?
| |      |         +--rw serial:port?     inet:port-number
| |      |         +--rw serial:remote
| |      |           +--rw serial:address    inet:ip-address
| |      |           +--rw serial:port?      inet:port-number
| |      +--ro serial:status
| |        +--ro serial:ip-tx-packets?      uint32
| |        +--ro serial:ip-tx-bytes?        uint32
| |        +--ro serial:ip-rx-packets?      uint32
| |        +--ro serial:ip-rx-bytes?        uint32
| |        +--ro serial:serial-tx-packets?   uint32
| |        +--ro serial:serial-tx-bytes?     uint32
| |        +--ro serial:serial-rx-packets?   uint32
| |        +--ro serial:serial-rx-bytes?     uint32
| +--rw fire:firewall
| | +--rw fire:enabled?   boolean
| | +--rw fire:filter [name]
| | | +--rw fire:name    sec:word-string
| | | +--rw fire:rule [id]
| | |    +--rw fire:id        uint32
| | |    +--rw fire:match
| | |    | +--rw fire:protocol?      protocol
| | |    | +--rw fire:icmp-type?     icmp-type
| | |    | +--rw fire:src-address?
| | |    | | +--rw (type)?
| | |    | |    +--:(address)
| | |    | |    | +--rw fire:address?        inet:ipv4-prefix
| | |    | |    +--:(address-range)
| | |    | |      +--rw fire:address-range
| | |    | |        +--rw fire:from    inet:ip-address
| | |    | |        +--rw fire:to?     inet:ip-address
| | |    | +--rw fire:src-port?
| | |    | | +--rw (type)?
| | |    | |    +--:(services)
| | |    | |    | +--rw fire:services*     service
| | |    | |    +--:(port-range)
| | |    | |      +--rw fire:port-range [from]
| | |    | |        +--rw fire:from    uint16
| | |    | |        +--rw fire:to?     uint16
| | |    | +--rw fire:dst-address?
| | |    | | +--rw (type)?
| | |    | |    +--:(address)
| | |    | |    | +--rw fire:address?        inet:ipv4-prefix
```

```
| | |    | |    +--:(address-range)
| | |    | |      +--rw fire:address-range
| | |    | |        +--rw fire:from    inet:ip-address
| | |    | |        +--rw fire:to?     inet:ip-address
| | |    | +--rw fire:dst-port?
| | |    | | +--rw (type)?
| | |    | |    +--:(services)
| | |    | |    | +--rw fire:services*     service
| | |    | |    +--:(port-range)
| | |    | |      +--rw fire:port-range [from]
| | |    | |        +--rw fire:from    uint16
| | |    | |        +--rw fire:to?     uint16
| | |    | +--rw fire:ipsec?
| | |    |    +--rw fire:direction           enumeration
| | |    |    +--rw fire:tunnel-src-address    inet:ipv4-prefix
| | |    |    +--rw fire:tunnel-dst-address    inet:ipv4-prefix
| | |    +--rw fire:actions?
| | |      +--rw fire:action        rule-action
| | |      +--rw fire:reject-type?   icmp-reject-type
| | |      +--rw fire:log?
| | |        +--rw fire:level?    syslog-level
| | |        +--rw fire:prefix?   sec:word-string
| | +--rw fire:nat
| |    +--rw fire:source
| |    | +--rw fire:rule-set [name]
| |    |    +--rw fire:name    sec:word-string
| |    |    +--rw fire:rule [id]
| |    |      +--rw fire:id          uint32
| |    |      +--rw fire:match
| |    |      | +--rw fire:src-address?   inet:ipv4-prefix
| |    |      | +--rw fire:dst-address?   inet:ipv4-prefix
| |    |      +--rw fire:source-nat
| |    |        +--rw (to)
| |    |          +--:(interface)
| |    |          | +--rw fire:interface?
| |    |          +--:(address)
| |    |            +--rw fire:address?     inet:ip-address
| |    +--rw fire:destination
| |      +--rw fire:rule-set [name]
| |        +--rw fire:name    sec:word-string
| |        +--rw fire:rule [id]
| |          +--rw fire:id              uint32
| |          +--rw fire:match
| |          | +--rw fire:protocol?      protocol
| |          | +--rw fire:src-address?   inet:ipv4-prefix
| |          | +--rw fire:dst-address?   inet:ipv4-prefix
| |          | +--rw fire:dst-port?      inet:port-number
| |          +--rw fire:destination-nat
| |            +--rw fire:address    inet:ip-address
| |            +--rw fire:port?      inet:port-number
| +--rw snmp:snmp
| | +--rw snmp:SNMPv1-enabled?     boolean
| | +--rw snmp:SNMPv2c-enabled?    boolean
| | +--rw snmp:SNMPv3-enabled?     boolean
| | +--rw snmp:ipv4-bind-ips*      leafref
```

```
| | +--rw snmp:ipv6-bind-ips*      leafref
| | +--rw snmp:port?              inet:port-number
| | +--rw (engine-id-method)?
| | | +--:(from-ip)
| | | | +--rw snmp:from-ip?          leafref
| | | +--:(from-mac-address)
| | |    +--rw snmp:from-mac-address?   empty
| | +--rw snmp:max-message-size?   int32
| +--rw ssh:ssh
| | +--rw ssh:enabled?        boolean
| | +--rw ssh:port?          inet:port-number
| | +--rw ssh:ipv4-bind-ips*   leafref
| | +--rw ssh:ipv6-bind-ips*   leafref
| +--rw vpn:vpn
| | +--rw vpn:enabled?           boolean
| | +--rw vpn:strict-crl-policy?   boolean
| | +--rw (type)?
| |   +--:(type-ipsec)
| |      +--rw vpn:ike?
| |      | +--rw vpn:policy [name]
| |      | | +--rw vpn:name             sec:word-string
| |      | | +--rw vpn:version?         ike-version
| |      | | +--rw vpn:mode?            ike-v1-mode
| |      | | +--rw vpn:auth-method      ike-auth-method
| |      | | +--rw vpn:pre-shared-key?   string
| |      | | +--rw vpn:pki?
| |      | | | +--rw vpn:cert-type     enumeration
| |      | | | +--rw vpn:cert-id       string
| |      | | | +--rw vpn:key-id        string
| |      | | | +--rw vpn:ca-cert-id    string
| |      | | +--rw vpn:ciphersuite [name]
| |      | | | +--rw vpn:name             sec:word-string
| |      | | | +--rw vpn:encryption-algo    encryption-algo
| |      | | | +--rw vpn:mac-algo          mac-algo
| |      | | | +--rw vpn:dh-group?         dh-group
| |      | | +--rw vpn:life-time?       uint16
| |      | | +--rw vpn:reauth?          boolean
| |      | +--rw vpn:peer [name]
| |      |    +--rw vpn:name                sec:word-string
| |      |    +--rw vpn:ike-policy           leafref
| |      |    +--rw vpn:local-endpoint
| |      |    | +--rw (ike-endpoint-type)?
| |      |    |    +--:(any)
| |      |    |    | +--rw vpn:any?
| |      |    |    +--:(address)
| |      |    |    | +--rw vpn:address?   inet:ip-address
| |      |    |    +--:(fqdn)
| |      |    |       +--rw vpn:fqdn?     string
| |      |    +--rw vpn:local-identity
| |      |    | +--rw (ike-identity-type)?
| |      |    |    +--:(default)
| |      |    |    | +--rw vpn:default?
| |      |    |    +--:(address)
| |      |    |    | +--rw vpn:address?    inet:ip-address
| |      |    |    +--:(fqdn)
```

```
| |      |   |   | +--rw vpn:fqdn?       string
| |      |   |   +--:(user-fqdn)
| |      |   |   | +--rw vpn:user-fqdn?   string
| |      |   |   +--:(dn)
| |      |   |     +--rw vpn:dn?         string
| |      |   +--rw vpn:peer-endpoint
| |      |   | +--rw (ike-endpoint-type)
| |      |   |   +--:(any)
| |      |   |   | +--rw vpn:any?
| |      |   |   +--:(address)
| |      |   |   | +--rw vpn:address?   inet:ip-address
| |      |   |   +--:(fqdn)
| |      |   |     +--rw vpn:fqdn?     string
| |      |   +--rw vpn:peer-identity
| |      |   | +--rw (ike-identity-type)?
| |      |   |   +--:(default)
| |      |   |   | +--rw vpn:default?
| |      |   |   +--:(address)
| |      |   |   | +--rw vpn:address?    inet:ip-address
| |      |   |   +--:(fqdn)
| |      |   |   | +--rw vpn:fqdn?       string
| |      |   |   +--:(user-fqdn)
| |      |   |   | +--rw vpn:user-fqdn?   string
| |      |   |   +--:(dn)
| |      |   |     +--rw vpn:dn?         string
| |      |   +--rw vpn:peer-identity-no-idr?   boolean
| |      |   +--rw vpn:role?                enumeration
| |      |   +--rw vpn:dpd-enabled?         boolean
| |      |   +--rw vpn:dpd-interval?        uint16
| |      +--rw vpn:ipsec?
| |        +--rw vpn:policy [name]
| |        | +--rw vpn:name          sec:word-string
| |        | +--rw vpn:ciphersuite [name]
| |        | | +--rw vpn:name             sec:word-string
| |        | | +--rw vpn:encryption-algo    encryption-algo
| |        | | +--rw vpn:mac-algo         mac-algo
| |        | | +--rw vpn:dh-group?        dh-group
| |        | +--rw vpn:life-time?    uint16
| |        +--rw vpn:connection [name]
| |        | +--rw vpn:name                  sec:word-string
| |        | +--rw vpn:ike-peer              leafref
| |        | +--rw vpn:ipsec-policy          leafref
| |        | +--rw (conn-type)
| |        | | +--:(net-to-net)
| |        | | | +--rw vpn:local-ip-subnet?         inet:ipv4-prefix
| |        | | +--:(host-to-net)
| |        | |   +--rw vpn:local-source-ip-address?   inet:ip-address
| |        | +--rw vpn:remote-ip-subnets*       inet:ipv4-prefix
| |        | +--rw vpn:is-out-of-band-ima?      boolean
| |        | +--rw vpn:failure-retry-interval?   uint8
| |        | +--rw vpn:periodic-retry-interval?   uint8
| |        +--ro vpn:ipsec-status
| |          +--ro vpn:connection [name]
| |            +--ro vpn:name              sec:word-string
| |            +--ro vpn:state?            enumeration
```

```
| |              +--ro vpn:failure-reason?       string
| |              +--ro vpn:last-timestamp?       yang:date-and-time
| |              +--ro vpn:ima-evaluation?       string
| |              +--ro vpn:ima-recommendation?   string
| +--rw web:web
|    +--rw web:http
|    | +--rw web:enabled?        boolean
|    | +--rw web:port?           inet:port-number
|    | +--rw web:ipv4-bind-ips*  leafref
|    | +--rw web:ipv6-bind-ips*  leafref
|    +--rw web:https
|       +--rw web:enabled?          boolean
|       +--rw web:port?             inet:port-number
|       +--rw web:ipv4-bind-ips*    leafref
|       +--rw web:ipv6-bind-ips*    leafref
|       +--rw web:tls-certificate?  string
|       +--rw web:tls-priv-key?     string
+--ro watchdog-status
| +--ro slab?                uint32
| +--ro slab-high-watermark?  uint32
| +--ro application-status [name]
|    +--ro name         string
|    +--ro status?      enumeration
|    +--ro fail-count?  uint32
|    +--ro age?         uint32
|    +--ro message?     string
+--rw watchdog
   +--rw enable?              boolean
   +--rw resource-monitor
   | +--rw period?  uint32
   | +--rw slab
   |    +--rw maximum?  uint32
   |    +--rw warning?  uint32
   +--rw polled-applications
   | +--rw period?       uint32
   | +--rw application [name]
   |    +--rw name       string
   |    +--rw severity?  enumeration
   +--rw reboot-triggers*       reboot-trigger-type
```

6.0 APPENDIX B – COMMAND LINE INTERFACE (CLI) FEATURES

Operational Mode

Operational Mode is the initial mode that the CLI is in right after logging in. Users can view operational and configuration data but cannot change configuration data. The prompt will show a “>” character when it is in operational mode.

Configuration Mode

Configuration mode is entered when the user types “configure” after logging in. Configuration Mode can be exited by typing “exit”, which brings the user back to Operational Mode. Configuration data can only be altered while the user is in Configuration Mode. The prompt will have a “%” character when it is in configuration mode.

Changing configuration data

Configuration data can only be changed while the CLI is in Configuration Mode. Changing configuration requires the two-step process described earlier, where changes can be made first and then must be committed to complete the process.

Once all the changes have been made, they can be committed using the “commit” command. If there is an error during the commit due to missing data, conflicting settings, or other issue, then none of the changes will be committed and the CLI will provide feedback regarding the error. The changes that were pending will still be pending at that point. This gives the user the opportunity to discard the changes or to modify them and then try to commit them again.

Inputting values

The format for each node in the data model is encoded in the data model itself. The CLI enforces the user input to be compliant to that format. There are several different formats of input, including numerics, strings, and limitations on the range and length of input. The CLI will provide assistance to the user when inputting values when the tab-completion feature is used (see Tab-completion section below).

The example below shows the “possible completions” when the TAB key is pressed after the word “location”. In this case, the node “location” can take a value that is a string with 0-255 characters.

admin@(none) 00:56:26% **set system location**

Possible completions:

<string, min: 0 chars, max: 255 chars>

admin@(none) 00:56:26% **set system location “Rochester, NY”**

[ok][2012-06-19 00:56:49]

[edit]

admin@(none) 00:56:49%

Inputting a list of values

A node can take a list of values if it has been defined that way in the data model. The CLI will indicate a node can take a list by displaying a bracket [, as shown below at the end of the possible completions information. Items in the list are separated by a space character.

This example shows that there are three ways to input values to a list node:

1. Without brackets, the value will be appended to the existing list **gemds**

2. With brackets, for a list that contains one value: “ [gemds] ”

3. With brackets, for a list that contains more than one value: “ [ge gemds] ”

admin@(none) 00:31:02% **set system dns search**

Possible completions:

<IP address> <string, min: 1 chars, max: 253 chars> [

admin@(none) 00:31:02% **set system dns search gemds**

[ok][2012-06-19 00:49:28]

[edit]

admin@(none) 00:49:28% **set system dns search [gemds]**

[ok][2012-06-19 00:49:34]

[edit]

admin@(none) 00:49:34% **set system dns search [ge gemds]**

[ok][2012-06-19 00:49:39]

[edit]

admin@(none) 00:49:39%

Tab-completion

Tab-completion is a powerful feature that presents CLI users with assistance while typing. Depending on the text that was already typed, tab-completion will display different possible completions.

When the tab key is pressed and no text has been typed, the CLI shows all of the possible commands that can be typed, as shown below. In this example, the CLI is in configuration mode and the following commands are relevant to configuration mode only.

admin@(none) 01:05:03%

Possible completions:

annotate - Add a comment to a statement
commit - Commit current set of changes
compare - Show configuration differences
copy - Copy a dynamic element
delete - Delete a data element
edit - Edit a sub-element
exit - Exit from this level
help - Provide help information
insert - Insert a parameter
move - Move a parameter
quit - Exit from this level
rename - Rename an identifier
request - Make system-level requests
resolved - Conflicts have been resolved
revert - Copy configuration from running

rollback - Roll back database to last committed version

run - Run an operational-mode command

set - Set a parameter

show - Show a parameter

status - Display users currently editing the configuration

tag - Manipulate statement tags

top - Exit to top level and optionally run command

up - Exit one level of configuration

validate - Validate current configuration

admin@(none) 01:05:03%

When the tab key is pressed after a typed command, then the CLI will show the user all the possible options that are pertinent to that command. In the example below the tab key was pressed after the word "set". The list of possible completions are shown to user.

admin@(none) 01:06:49% set

Possible completions:

certmgr -

file-servers -

interfaces - Interface parameters.

logging -

routing - Routing parameters.

services - Services which are configurable on this system

system - System group configuration.

admin@(none) 01:06:49% set

When the tab is key is pressed after the name of a data node that the user is trying to configure, then the CLI will show the user the format of the data that is acceptable for that data node. In the example below, the tab key was pressed after the word "search". In this case, the node "search" can take a list of values that are IP addresses or strings, each with 0-255 characters.

admin@(none) 00:31:02% set system dns search

Possible completions:

<**IP address**> <**string, min: 1 chars, max: 253 chars**> [

admin@(none) 00:31:02% set system dns search mds

[ok][2012-06-19 00:49:28]

[edit]

CLI Environment

There are a number of session variables in the CLI. They are only used during the session and are not persistent. Their values are inspected using "show cli" in operational mode, and set using set in operational mode.

```
admin@(none) 17:19:11> show cli
autowizard true;
complete-on-space true;
```

```
display-level 99999999;
history 100;
idle-timeout 1800;
ignore-leading-space false;
output {
   file terminal;
}
paginate true;
prompt1 \u@\h\M \t> ;
prompt2 \u@\h\M \t% ;
screen {
   length 24;
   width 80;
}
show {
   defaults false;
}
terminal linux;
[ok][2012-06-19 17:19:12]
admin@(none) 17:19:12>
```

The different values control different parts of the CLI behavior.

autowizard (true | false)

When enabled, the CLI will prompt the user for required settings when a new identifier is created and for mandatory action parameters.

For example, the "filename" parameter will be requested from the user since it is mandatory and yet it was not supplied in the initial request:

```
admin@(none) 00:09:38% request system firmware reprogram-inactive-image preconfigured-file-server {
configuration_name fs1 }
Value for 'filename' (<string>): fw.pkg
[ok][2012-06-19 00:09:48]
```

To avoid prompting, it is recommended to disable the autowizard before pasting in a list of commands. A good practice is to start all such scripts with a line that disables the autowizard:

```
set autowizard false
...
set autowizard true
```

complete-on-space (true | false)

Controls if command completion should be attempted when <space> is entered. Entering <tab> always results in command completion.

ignore-leading--space (true | false)

Controls if leading spaces should be ignored or not. This is useful to turn off when pasting commands into the CLI.

history (<integer>)

Size of CLI command history.

idle-timeout (<seconds>)
Maximum idle time before being logged out. Use 0 (zero) for infinity.

paginate (true | false)
Some commands paginate their output, for example. This can be disabled or enabled. It is enabled by default.

screen width (<integer>)
Current width of terminal. This is used when paginating output to get proper line count.

screen length (<integer>)
Current length of terminal. This is used when paginating output to get proper line count.

terminal (string)
Terminal type. This setting is used for controlling how line editing is performed. Supported terminals are: dumb, vt100, xterm, linux, and ansi. Other terminals may also work but have no explicit support.

Command output processing

It is possible to process the output from a command using an output redirect. This is done using the | character. The commands can be chained to achieve more complex processing.

```
admin@(none) 17:20:27> show configuration |
Possible completions:
  annotation - Show only statements whose annotation matches a pattern
  count      - Count the number of lines in the output
  csv        - Emit table output in CSV format
  details    - Display details
  display    - Display options
  except     - Show only text that does not matches a pattern
  extended   - Show referring elements
  find       - Search for the first occurrence of a pattern
  hide       - Hide display options
  linnum     - Enumerate lines in the output
  match      - Show only text that matches a pattern
  match-all  - All selected filters must match
  match-any  - At least one filter must match
  more       - Paginate output
  nomore     - Suppress pagination
  select     - Select additional columns
  tab        - Enforce table output
  tags       - Show only statements whose tags matches a pattern
  until      - Display until the first occurrence of a pattern
admin@(none) 17:20:27> show configuration |
```

Count the Number of Lines in the Output

This redirect target counts the number of lines in the output. For example:

```
admin@io 13:28:07> show configuration | count
```

```
[ok][2007-08-31 13:49:44]
Count: 99 lines
admin@io 13:49:44> show configuration interfaces | count
[ok][2007-08-31 13:50:12]
Count: 90 lines
admin@io 13:50:12>
```

Search for a String in the Output

The match target is used to only include lines matching a regular expression. For example:

```
admin@(none) 00:19:57> show configuration logging | match date
event-rules date_time_from_ntp {
event-rules date_time_from_user {
event-rules date_time_not_set {
[ok][2012-06-19 00:20:02]
admin@(none) 00:20:02>
```

In the example above only lines containing “date” are shown. Similarly lines not containing a regular expression can be included.

```
admin@(none) 00:22:13> show interfaces | except counters
interfaces supported-interfaces bridge true
interfaces interface eth0
 if-index 2
 status mac-address 1e:ed:19:27:1a:b3
 status mtu  1500
 status link up
 status ipv4 address [ 192.168.1.10/24 ]
 status ipv6 address [ fe80::1ced:19ff:fe27:1ab3/64 ]
[ok][2012-06-19 00:22:19]
admin@(none) 00:22:19>
```

It is also possible to display the output starting at the first match of a regular expression, using the find target. For example:

```
admin@(none) 00:23:51> show interfaces | find tx
 status counters tx_aborted_errors 0
 status counters tx_bytes 238574
 status counters tx_carrier_errors 0
 status counters tx_compressed 0
 status counters tx_dropped 0
 status counters tx_errors 0
 status counters tx_fifo_errors 0
 status counters tx_heartbeat_errors 0
 status counters tx_packets 1731
 status counters tx_window_errors 0
[ok][2012-06-19 00:23:53]
admin@(none) 00:23:53>
```

Output can also be ended when a line matches a regular expression. This is done with the until target.

For example:

```
admin@(none) 00:24:37> show interfaces | find tx | until compressed
 status counters tx_aborted_errors 0
 status counters tx_bytes 250246
 status counters tx_carrier_errors 0
 status counters tx_compressed 0
[ok][2012-06-19 00:24:43]
admin@(none) 00:24:43>
```

Regular expressions

The regular expressions is a subset of the regular expressions found in egrep and in the AWK programming language. Some common operators are:

.	Matches any character.
^	Matches the beginning of a string.
$	Matches the end of a string.
[abc...]	Character class, which matches any of the characters abc... Character ranges are specified by a pair of characters separated by a -
[^abc...]	negated character class, which matches any character except abc....
r1 | r2	Alternation. It matches either r1 or r2.
r1r2	Concatenation. It matches r1 and then r2.
r+	Matches one or more rs.
r*	Matches zero or more rs.
r?	Matches zero or one rs.
(r)	Grouping. It matches r.

For example, to only display **uid** and **gid** you can do the following:

```
admin@io 15:11:24> show configuration | match "(uid)|(gid)"
uid 1000;
gid 100;
uid 1000;
gid 100;
uid 1000;
gid 100;
uid 1000;
gid 100;
```

Display line numbers

The linnum target causes a line number to be displayed at the beginning of each line in the display.

```
admin@io 15:11:24> show configuration | match "(uid)|(gid)" | linnum
1: uid 1019;
2: gid 1013;
3: uid 1019;
4: gid 1013;
5: uid 1019;
6: gid 1013;
```

7: uid 1019;
8: gid 1013;

Showing information

Control Sequences

The default key strokes for editing the command line and moving around the command history are as follows.

Move the cursor back one character	Ctrl-b or Left Arrow
Move the cursor back one word	Esc-b or Alt-b
Move the cursor forward one character	Ctrl-f or Right Arrow
Move the cursor forward one word	Esc-f or Alt-f
Move the cursor to the beginning of the command line	Ctrl-a or Home
Move the cursor to the end of the command line	Ctrl-e or End
Delete the character before the cursor	Ctrl-h, Delete, or Backspace
Delete the character following the cursor	Ctrl-d
Delete all characters from the cursor to the end of the line	Ctrl-k
Delete the whole line	Ctrl-u or Ctrl-x
Delete the word before the cursor	Ctrl-w, Esc-Backspace, or Alt-Backspace
Delete the word after the cursor	Esc-d or Alt-d
Insert the most recently deleted text at the cursor	Ctrl-y
Scroll backward through the command history	Ctrl-p or Up Arrow
Scroll forward through the command history	Ctrl-n or Down Arrow
Search the command history in reverse order	Ctrl-r
Show a list of previous commands	run the “show cli history” command
Capitalize the word at the cursor	Esc-c
Change the word at the cursor to lowercase	Esc-l
Change the word at the cursor to uppercase	Esc-u
Abort a command/Clear line	Ctrl-c
Quote insert character	Ctrl-v/ESC-q
Redraw the screen	Ctrl-l
Transpose characters	Ctrl-t
Enter multi-line mode	ESC-m

Commands

The commands available to the user differs, depending on whether the CLI is in operational mode or configuration mode. The following commands are describe in the next sections:

Operational Mode Commands	Configuration Mode Commands
commit	annotate
configure	commit
exit	compare
help	copy

ping	delete
quit	edit
request	exit
set	help
set-path	insert
show	move
ssh	quit
top	rename
traceroute	request
up	resolved
	revert
	rollback
	run
	set
	show
	status
	tag
	top
	up
	validate

Operational mode commands

commit (abort | confirm) [persist-id <id>]

Abort or confirm a pending confirming commit. A pending confirming commit will also be aborted if the CLI session is terminated without doing commit confirm (default is confirm).

If the confirming commit was initiated with a persist argument, then the same token needs to be supplied using the persist-id argument to this command.

Configure (private, exclusive, shared)

Enter configure mode. The default is private.

Private

Edit private copy of running configuration

Exclusive

Lock and edit candidate configuration.

Shared

Edit candidate configuration without locking it.

exit

Exits the CLI session.

help <command>

Display help text related to <command>.

ping

Ping an IP address or hostname.

request

Performs a Remote Procedure Call, which instructs the device to perform some operation, i.e., a reboot.

script
To be supplied.

set [environment]
See section "CLI Environment"

set-path
Set relative show path

show [path]
Display CLI properties.

show configuration
The "show" command can be used to view information. Notice the information displayed is different, depending on which mode the CLI is in.

Showing operational data when the CLI is in operational mode:

```
admin@(none) 01:25:01> show system
system platform os-name Linux
system platform os-release 3.0.15-mds-01466-gc578a6a
system platform os-version "#1 SMP PREEMPT Mon Nov 19 17:56:10 EST 2012"
system platform machine armv7l
system platform nodename (none)
system clock current-datetime 2012-06-19T01:25:05+00:00
system clock boot-datetime 2012-06-19T00:00:34+00:00
system support support-transfer-status state "Not Started"
system support support-transfer-status detailed-message ""
system support support-transfer-status size 0
system support support-transfer-status bytes-transfered 0
system support support-transfer-status percent-complete 0

                                 CERTIFICATE
                                 SIGNING      CERTIFICATE
LOCATION  VERSION       ACTIVE   INDEX        SHA256
-------------------------------------------------------
1         not found     false
2         0.0.3-1130-a  true

[ok][2012-06-19 01:25:05]
admin@(none) 01:25:05>
```

Showing configuration data when the CLI is in operational mode:

```
admin@(none) 01:24:05> show configuration system name
name "Device #42";
[ok][2012-06-19 01:24:30]
admin@(none) 01:24:30> show configuration system
```

```
name                "Device #42";
serial-number-core    42;
serial-number-platform 42;
pre-login-banner      "";
[ok][2012-06-19 01:24:31]
admin@(none) 01:24:31>
```

Showing configuration data when the CLI is in configuration mode:

```
admin@(none) 01:25:36% show system
name                "Device #42";
serial-number-core    42;
serial-number-platform 42;
pre-login-banner      "";
[ok][2012-06-19 01:25:43]

[edit]
admin@(none) 01:25:43%
```

Normally, only those values explicitly set by the user will be displayed. Users can selectively view those nodes that assumed a default value by using the "details" modifier on the CLI.

Showing the user's configuration and any nodes that assumed a default value:

```
admin@(none) 16:28:52> show configuration interfaces interface ETH1 | details
type    ethernetCsmacd;
enabled true;
ipv4 {
   enabled      true;
   ip-forwarding false;
   address 192.168.1.10 {
      prefix-length 24;
   }
}
ipv6 {
   enabled              true;
   ip-forwarding        false;
   dup-addr-detect-transmits 1;
   autoconf {
      create-global-addresses      true;
      create-temporary-addressed   false;
      temporary-valid-lifetime     604800;
      temporary-preferred-lifetime 86400;
   }
}
[ok][2012-06-19 16:28:55]
admin@(none) 16:28:55>
```

Showing the complete data model that the user has access to, while using additional CLI features:

```
admin@(none) 23:51:18> show configuration | details | display set | nomore
set logging event-rules console_login description ""
set logging event-rules console_login local true
set logging event-rules console_login priority notice
```

.....
<TEXT OMMITTED FOR BREVITY>
.....

ssh
Open a secure shell on another host

top
Exit to top level and optionally run command

traceroute
Trace the route to a remote host

up
Exit one level of configuration

Configure mode commands

annotate <statement> <text>
Associate an annotation with a given configuration statement. To remove an annotation leave the text empty.

compare running [brief]
If changes have been made, but have not yet been committed, then those changes can be reviewed prior to committing them by using the "compare" command. Differences will be annotated with - (removed) and + (added). If the brief option is specified, then only the differences will be shown.

tag add <statement> <tag>
Add a tag to a configuration statement.

tag del <statement> <tag>
Remove a tag from a configuration statement.

tag clear <statement>
Remove all tags from a configuration statement.

commit (check | and-quit | confirmed [<timeout>] [persist <token>] to-startup) [comment <text>] [label <text>] [persist-id <id>]
Commit current configuration to running.

check
Validate current configuration.

and-quit
Commit to running and quit configure mode.

confirmed
Commits the current configuration to running with a timeout. If no **commit confirm** command has been issued before the timeout expires, then the configuration will be reverted to the

configuration that was active before the **commit confirmed** command was issued. If no timeout is given then the confirming commit will have a timeout of 10 minutes. The configuration session will be terminated after this command since no further editing is possible. Only available in configure exclusive and configure shared mode.

The confirming commit will be rolled back if the CLI session is terminated before confirming the commit, unless the persist argument is given. If the persist command is given then the CLI session can be terminated and a later session may confirm the pending commit by supplying the persist token as an argument to the commit command using the persist-id argument.

comment <text>
Associate a comment with the commit. The comment can later be seen when examining rollback files.

label <text>
Associate a label with the commit. The label can later be seen when examining rollback files.

persist-id <id>
If a prior confirming commit operation has been performed with the persist argument, then to modify the ongoing confirming commit process the persist-id argument needs to be supplied with the same persist token. This makes it possible to, for example, abort an ongoing persist commit, or extend the timeout.

validate
Validates current configuration. This is the same operation as commit check.

insert <path>
Inserts a new element. If the element already exists and has the indexedView option set in the data model, then the old element will be renamed to element+1 and the new element inserted in its place.

insert <path>[first|last|beforekey|afterkey]
Insert a new element into an ordered list. The element can be added first, last (default), before or after another element.

move <path>[first|last|beforekey|afterkey]
Move an existing element to a new position in an ordered list. The element can be moved first, last (default), before or after another element.

rename <instance path> <new id>
Rename an instance.

exit (level | configuration-mode)

level
Exit from current mode. If performed on the top level, will exit configure mode. This is the default if no option is given.

configuration-mode
Exit from configuration mode regardless of mode.

help <command>
Shows help text for command.

revert
If changes have been made, but have not yet been committed, then those changes can be committed, reverted, or ignored by quitting the configuration mode of the CLI. Reverting the changes can be done using the “revert” command.

rollback [<number>]
Return the configuration to a previously committed configuration. The system stores a limited number of old configurations. If more than the configured number of configurations are stored, then the oldest configuration is removed before creating a new one. The most recently committed configuration (the running configuration) is number 0, the next most recent 1, etc.
Example:

```
admin@(none)% rollback 1
[ok][2012-06-19 16:28:55]
admin@(none)%
```

7.0 APPENDIX C – INTEGRITY MEASUREMENT AUTHORITY (IMA)

Understanding

The MCR supports the integrity measurement and attestation architecture as described by Trusted Network Connect (TNC) specifications, jointly developed and published by Trusted Computing Group (TCG) and IETF NEA working group.

The MCR establishes secure IPsec VPN connection with the VPN gateway via mutual authentication based on certificates or pre-shared secrets. The TNC architecture adds the ability to measure, report and verify the security state of the MCR (e.g. integrity of critical system configuration file) as a part of IPsec VPN authentication and authorization process.

MCR supports TNCCS 2.0 protocol and subset of TCG's Platform trust Service (PTS). The MCR supports only file measurement capability of the PTS protocol. Also, only measurements for following files are supported:

1. **/tmp/system.config** - This file includes all current system configuration.
2. **/etc/tnc_config**

Once the unit has been configured, the hash (sha256 or sha385) of system configuration file can be obtained via CLI (locally or remotely) and loaded into the Integrity Measurement Authority (IMA) database.

Typically, integrity measurement and attestation happens automatically as part of IPsec VPN "data" connection establishment using EAP-TTLS method (and EAP-TNC authentication within it) as instructed by the VPN-gateway. However, MCR also supports an out-of-band IMA connection, where the unit connects to a separate IMA server not to pass data but just to perform integrity measurement and attestation. The IMA server, in such a setup, can then publish the unit's "health" information to the VPN server that is terminating the actual data connections. This allows VPN server to enforce permit/deny policy for incoming VPN data connections from the unit.

Configuring

The out of band IMA configuration is exactly similar to VPN configuration described in VPN section except that the IPsec connection is designated specifically as out-of-band IMA connection and local and remote ip subnet are all set 0.0.0.0/0 as shown below:

admin@(none) 21:51:32> admin@(none) 19:33:29% set services vpn ipsec connections connection IMA-CONN-1 is-out-of-band-ima true

admin@(none) 21:51:32> admin@(none) 19:33:29% set services vpn ipsec connections connection IMA-CONN-1 local-ip-subnet 0.0.0.0/0

admin@(none) 21:51:32> admin@(none) 19:33:29% set services vpn ipsec connections connection IMA-CONN-1 remote-ip-subnet 0.0.0.0/0

```
admin@(none) 21:51:32> admin@(none) 19:33:29% set services vpn ipsec connections connection
IMA-CONN-1 periodic-retry-interval 60
```

The “periodic-retry-interval” applies only to the IPsec connection designated as an “out-of-band” IMA connection. The MCR attempts attestation every “periodic-retry-interval” if the previous attempt to connect with IMA server was unsuccessful.

In case of an out of band IMA server setup, the MCR needs to be configured with an IMA IPsec connection and a VPN-GWY IPsec connection. For example:

```
connection IMA-CONN-1 {
   ike-peer                IMA-SERVER;
     ipsec-policy            IPSEC-POLICY-IMA;
     local-ip-subnet         0.0.0.0/0;
     remote-ip-subnet        0.0.0.0/0;
     is-out-of-band-ima      true;
     failure-retry-interval 1;
}
connection VPN-GWY-CONN-1 {
    ike-peer                VPN-GWY;
     ipsec-policy            IPSEC-POLICY-1;
     local-ip-subnet         192.168.1.0/24;
     remote-ip-subnet        192.168.2.0/16;
     failure-retry-interval 1;
}
```

IMA-CONN-1 is used for attestation and VPN-GWY-CONN-1 is used for VPN data connection.

If more than one IPsec connection is configured on the unit, the unit initiates connections in round-robin fashion. For example, MCR will follow the following sequence:

- Attempt connection to IMA-SERVER
- Attempt connection to VPN-SERVER (irrespective of IMA-SERVER connection outcome)
- Attempt connection to IMA-SERVER after failure-retry-interval if previous attempt to connect with it failed.
- Attempt connection to IMA-SERVER after periodic-retry-interval if previous attempt to connect with it succeeded.
- Attempt connection to VPN-SERVER after failure-retry-interval if it failed previously or got disconnected due to dead peer detection.
- and so on…

Obtaining Configuration file hash

The following example shows the use of a request to get the system configuration hash:

```
admin@(none) 22:09:59> request service-vpn-ipsec-get-config-hash hash-algo sha384
```

```
hash
e60429aa127cb2f23e10ae00b6c1553fa9d1f598b2a206926ad0dcdf9a758622eec77ad559b32f85ceea901
3a961041f
[ok][2013-01-18 22:10:15]
```

This hash can then be loaded in IMA database.

Monitoring

The current attestation status of the IMA connection is displayed using same command as used to display regular VPN data connection status. The example, below shows that the IMA connection succeeded but the IMA Evaluation was “non-compliant” and IMA recommendation was “Quarantined”. This will happen is the system configuration file hash loaded in IMA does not match the actual hash of the current system configuration, indicating that system configuration was changed since last time the hash was loaded in the IMA database.

```
admin@(none) 22:10:15> show services vpn
services vpn ipsec ipsec-status connections connection IMA-CONN-1
 state              disconnected
 failure-reason     none
 last-timestamp     2013-01-18T21:24:26+00:00
 ima-evaluation     “non-compliant major”
 ima-recommendation Quarantined
[ok][2013-01-18 22:13:20]
```

Once it is determined, through event logs that the configuration was changed by authorized user, the current configuration hash can be loaded in the IMA and then MCR can be instructed to re-attest with IMA server, as shown below.

```
admin@(none) 22:18:45> request service-vpn-ipsec-attest-with-ima conn-name IMA-CONN-1
[ok][2013-01-18 22:18:52]
```

The IMA status can then be checked again periodically for new attestation result:

```
admin@(none) 22:10:15> show services vpn
services vpn ipsec ipsec-status connections connection IMA
 state              disconnected
 failure-reason     none
 last-timestamp     2013-01-18T22:19:02+00:00
 ima-evaluation     compliant
 ima-recommendation “Access Allowed”
[ok][2013-01-18 22:19:37]
```

IMA Troubleshooting

Follow the troubleshooting steps described in VPN section on troubleshooting IMA connection failure. Note that an IMA connection failure means that unit was unable to communicate or attest with IMA. It does not mean there was an IMA evaluation failure.

APPENDIX D – Common Event Expression (CEE)

Events will be categorized using a taxonomy based on the Common Event Expression (CEE) event profile (1). These events will be encoded using JavaScript Object Notation (JSON), and placed into the standard message body of a syslog message.

From the CEE website:

Common Event Expression (CEE™) improves the audit process and the ability of users to effectively interpret and analyze event log and audit data. This is accomplished by defining an extensible unified event structure, which users and developers can leverage to describe, encode, and exchange their CEE Event Records. (2)

CEE defines the structure of event messages via an XML schema referred to as the CEE Core Profile. The Core Profile consists of 3 reusable components: (2)

- **Event Taxonomy** — provides a listing of Event Tags that can be used to classify and identify events. The taxonomy supports common event categorization methods and identification of records that pertain to similar types of events.

- **Field Dictionary** — a listing of event record fields and field value types used to represent common event data. Selected fields and value types become associated with properties of a specific event instance.

- **CEE Event Schema** — defines the structure of an event record, including the minimum set of required fields. Event Extensions provide a mechanism for capturing additional data about an event.

One of the key features of the CEE Core Profile is that it can be extended by an organization so that they can add additional taxonomy categories and fields that describe vendor specific events.

Event Taxonomy

The CEE Core Profile defines the following taxonomy categories:

- **Action** — The primary type of action that was undertaken as part of the event. The status or result of the action should be detailed in the status field.

- **Domain** — The environment or domain of the event. Typical event domains include network (net), operating system (os), and application (app).

- **Object** — The type of object that is targeted or otherwise affected by the event

- **Service** — The service the event involves. The service field value provides context to the event action or more precision to the event domain.

- **Status** — The end result or status of the event action identified by the action field.

- **Subject** — The type of object that initiated or started the event action identified by the action field.

With the exception of 'subject', the Core Profile defines valid values for each of these categories, some examples of the values include "access, copy, clone, encrypt" for action values, and "error, failure, ongoing, success" for status values.

All taxonomy fields are optional, however if given they *must* contain exactly one non-null value.

Event Field Dictionary

The Core Profile defines a selection of common fields that may be used in event logs. Like the taxonomy categories, this dictionary can be extended by vendors by using a custom profile. All of the defined fields are optional with the exception of the following 3 mandatory fields that must be in every logged event:

- **host** – Hostname of the event source.
- **pname** – Process name that generated the event.
- **time** – Event start time

It may appear that having the time field is redundant, as the time is already in the syslog message; this is false for 2 reasons:

1. RFC 3164 (3) Syslog timestamps do not contain the year, and only have second resolution, whereas the CEE timestamps have microsecond resolution with full year. RFC 5424 (4) Syslog messages do include the year and support for microsecond resolution.
2. Syslog timestamps reflect the time that the event was sent to syslog, not necessarily the time that the event occurred. Depending on the situation, these times may be different.

Event Encoding & Transport

CEE defines two different methods for encoding events for transport and storage, XML and JSON. CEE also explicitly defines how CEE messages are to be transported over syslog (5). The following requirements are stated:

- Syslog Header – The standard Syslog header MUST be used.
- Syslog Body – The CEE Event MUST be represented using the CLS (CEE common Log Syntax) JSON Encoding.
    - CEE Event Flag – The beginning of the encoded CEE Event MUST be identified by the CEE Event Flag. Within Syslog, the CEE Event Flag is @cee:
- Character Encoding – If the syslog implementation is only 7-bit, all characters not in the ASCII character set MUST be escaped.

Examples

A valid CEE JSON Event Record embedded within an RFC5424 Syslog transport:

```
<165>1 2011-12-20T12:38:06Z 10.10.0.1 process - example-event-1
@cee:{"pname":"auth","host":"system.example.com","time":"2011-12-20T12:38:05.123456-05:00"}
```

A valid CEE JSON Event Record used with a “legacy” Syslog transport:

```
<0>Dec 20 12:42:20 syslog-relay process[35]: @cee:
{"crit":123,"id":"abc","appname":"application","pname":"auth","pid":123,"host":"system.example.com","pri":10,"time":"2011-12-20T12:38:05.123456-05:00","action":"login","domain":"app","object":"account","service":"web","status":"success"}
```

The following example shows a series of events that may be generated by a host requesting an IP for its eth0 interface from a DHCP server (Syslog header left off for brevity, and formatted for clarity):

DHCP Request sent to the server:

```
@cee: {
"host":"stout",
"pname":" my_appname ",
"time":"2012-08-22T11:20:10.559227-04:00",
"action":"request",
"domain":"net",
"object":"interface",
"service":"dhcp_client",
"status":"ongoing",
"event":"dhcp_client",
"interface_name":"eth0",
"profile":http://gemds.com/cee_profile/1.0beta1.xsd
}
```

DHCP Response from server, assigning the IP 192.168.2.3:

```
@cee: {
"host":"stout",
"pname":"my_appname",
"time":"2012-08-22T11:20:10.559748-04:00",
"action":"request",
"domain":"net",
"object":"interface",
"service":"dhcp_client",
"status":"success",
"ipv4":"192.168.2.3",
"event":"dhcp_client",
"interface_name":"eth0",
"profile":http://gemds.com/cee_profile/1.0beta1.xsd
}
```

The body of syslog messages of type “alert” is specified using RFC 5425 type key/value pairs. A few additional fields are also present.

syslog PRIVAL

The “PRIVAL” field of the syslog “HEADER” shall to be set to 113 for alerts and between 104 and 111 for auditable events.

syslog APP-NAME

The “APP-NAME” field of the “HEADER” specified in the syslog RFC shall be set to “csmgr”.

RFC5424 states: “The APP-NAME field SHOULD identify the device or application that originated the message.” The semantics of the field have changed from the application that originated the event, to the application who should receive the event.

syslog MSG

For events of type audit, the msg is vendor specific, whereas events of type alert must be in a specified format which contains a GUID, level and message. Using the CEE approach all of the requested information would be present in all messages.

Example of message using format

Jun 7 11:10:22 ccc99 csmgr[27417]: Source=' ABCDEF0123456789AB00000000000099' Level='5' Message='Date/Time Changed by User'

Example of message using CEE format

Jun 7 11:10:22 ccc99 systemmgr[33212]: @cee: {"host":"ccc99","guid":" ABCDEF0123456789AB00000000000099","syslog_priority":5, "pname":"systemmgr","time":"2012-08-23T09:16:21.335592-04:00","action":"modify","domain":"os","object":"datetime", "status":"success","event":"date_time_from_user","profile":"http://gemds.com/cee_profile/1.0beta1.xsd"}

Configuring

The following shows how to configure the unit with a server to which events will be sent:

admin@(none) 03:58:13% set logging syslog server my_syslog_server ip 192.168.1.1 port 1999 protocol tls version RFC5424 tls-options tls-ca-certificate my_ca_cert tls-client-certificate my_client_cert tls-client-key my_client_key

The following shows how to configure an event that will be logged locally, via syslog, and via netconf-notifcations:

admin@(none) 00:12:19% set logging event-rules cell_connected syslog true local true netconf-notification true

Monitoring

Ensure the CLI is in operational mode. Follow the example below to view the state and statistics

```
admin@(none) 00:14:24% show logging
event-rules cell_connected {
    description          "cell connection established";
    local                true;
    priority             notice;
    syslog-facility      user;
    syslog               true;
    snmp-trap            true;
    netconf-notification true;
}
event-rules cell_disconnected {
    description          "cell connection disconnected";
    local                true;
    priority             notice;
    syslog-facility      user;
    syslog               true;
    snmp-trap            true;
    netconf-notification true;
}
...
[ok][2012-06-19 00:15:03]

[edit]
admin@(none) 00:15:03%
```

APPENDIX E– Configuring Firmware Management

The GE MDS code signing tool (CST) is a command line program that can be run on Windows or Linux. Running the CST and passing the "--help" argument will print the following usage info:

```
pkgsigner --help

GEMDS Firmware Packaging Signing Utility (pkgsigner) 06-6671A01 Rev. 0.3.0
Built: Jan  7 2013 11:25:34

Usage:
To verify and sign a package:
  pkgsigner -v verifycert -k privkey -P password -p pubcert -f infile -o outfile

  where:  verifycert = The filepath a public certificate to be used to verify the
                  signature of the infile if and the infile has been
                  previously signed.
          privkey = The filepath for the private key to be used to create
                  a signed package.
         password = The optional password, if the private key is encrypted
          pubcert = The filepath for the public certificate corresponding to
                  the privkey. This is use to store a hash of the certificate
                  information, to aide lookup of the appropriate public key
                  during signature verification
           infile = The filepath for package file (input)
          outfile = The filepath for signed package file (output)

To display package info and verification status:
  pkgsigner -l -v verifycert -f infile
  where:  verifycert = The filepath a public certificate to be used to verify the
                  signature of the infile if and the infile has been
                  previously signed.
           infile = The filepath for package file (input)
```

Users can verify that a firmware package file came from GE MDS by using the CST. The following example shows how to verify a signed firmware package file came from GE MDS by using the firmware file **ge_signed_package.mpk** and by using the GE MDS provided public certificate **ge_pubcert.pem**.

```
./pkgsigner -l -v ge_pubcert.pem -f ge_signed_package.mpk
Processing file: 'ge_signed_package.mpk'
Package ID: 20121101
NumImages: 4
NumSignatures: 1
Image #0 : Bootloader version 2012.07-g644d99
Image #1 :     Kernel version 3.0.15-mds-gc00
Image #2 :     RootFS version 0.0.4
Image #3 :     CompFS version 0.0.0
Package version: 0.0.4

Signature #1 validation was successful.
```

Signing a GE MDS firmware package is an optional step for users and is not required. Users may wish to sign a firmware package to ensure that only user-approved firmware package revisions from GE MDS can be loaded into a unit. An example of signing a firmware package is shown below:

```
./pkgsigner -v ge_pubcert.pem -k user_key.pem -P "mypass" -p user_pubcert.pem -f
ge_signed_package.mpk -o user_signed_package.mpk

Processing file: 'ge_signed_package.mpk'
Package ID: 20121101
NumImages: 4
NumSignatures: 1
Image #0 : Bootloader version 2012.07-g644d99
Image #1 :    Kernel version 3.0.15-mds-gc00
Image #2 :    RootFS version 0.0.4
Image #3 :    CompFS version 0.0.0
Package version: 0.0.4

Signature #1 validation was successful.

Packed file created in 'user_signed_package.mpk'.
```

Where:

- **ge_signed_package.mpk** is the firmware package provided by GE MDS that was signed by GE MDS. Firmware packages will typically be downloaded by users from GE MDS websites.
- **ge_pubcert.pem** is the public certificate provided by GE MDS that is used to verify that the signed packaged is authentic. The GE MDS public certificate will typically be downloaded by users from the GE MDS website.
- **user_key.pem** is a private key provided by the user.
- **mypass** is the password used to decrypt *user_key.pem*, assuming the key is password protected. If the key is not password protected, then the –P option may be omitted.
- **user_pubcert.pem** is the public certificate corresponding to *user_key.pem*.
- **user_signed_package.mpk** the file that will be created that contains the GE MDS signature and the newly appended user signature.

When verifying a user-signed package, both the GE MDS public certificate and the user's public certificate must be provided to the CST:

```
./pkgsigner -l -v ge_pubcert.pem -v user_pubcert.pem -f user_signed_package.mpk

Processing file: 'user_signed_package.mpk'
Package ID: 20121101
NumImages: 4
NumSignatures: 2
Image #0 : Bootloader version 2012.07-g644d99
Image #1 :    Kernel version 3.0.15-mds-gc00
Image #2 :    RootFS version 0.0.4
Image #3 :    CompFS version 0.0.0
Package version: 0.0.4

Signature #2 validation was successful.
Signature #1 validation was successful.
```

APPENDIX F– Obtaining Provisioned Cell Service (Verizon)

Understanding

The MDS Orbit MCR-4G requires a mini SIM card (2FF type) provisioned for 4G cell operation. The unit's cellular interface will not function without a valid SIM card installed.

GE MDS does not provide SIM cards. Service can be obtained by contacting Verizon and requesting a provisioned SIM card for the appropriate M2M service plan.

Description of the SIM port and how to insert a SIM card is provided in "Connectors and Indicators" on Page 4 of this manual.

Before Contacting Verizon

To enable service, Verizon will typically require the IMEI (International Mobile Equipment Identity) of the equipment in which the SIM card will be used.

The IMEI can be found by logging into the device and entering the following command:

admin@(none) 00:20:44> show interfaces interface Cell cell-status imei

cell-status imei 991000947608727

If MEID (Mobile Equipment Identifier) is needed, this is equal to the IMEI value *minus the last digit.*

NOTE: Do not run the command above unless a provisioned SIM card is installed in the unit. If an un-provisioned card is used, the cell-status may return an error code beginning with **0x** instead of the proper IMEI value.

Establishing a Cell Service Plan

Verizon offers a variety of service plans. Determine your data needs and contact your Verizon Wireless Business Representative to obtain the appropriate provisioned SIM cards.

Verizon provides the following link to assist in finding a service representative based on customer attributes and needs: **https://www.findmyrep.vzw.com/**

8.0 APPENDIX G – LICENSES

++++++++++++++SQLCiper++++++++++++++++++

<http://sqlcipher.net/license/>

Copyright (c) 2008-2012 Zetetic LLC
All rights reserved.

Redistribution and use in source and binary forms, with or without
modification, are permitted provided that the following conditions are met:
* Redistributions of source code must retain the above copyright
notice, this list of conditions and the following disclaimer.
* Redistributions in binary form must reproduce the above copyright
notice, this list of conditions and the following disclaimer in the
documentation and/or other materials provided with the distribution.
* Neither the name of the ZETETIC LLC nor the
names of its contributors may be used to endorse or promote products
derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY ZETETIC LLC "AS IS" AND ANY
EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED
WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE
DISCLAIMED. IN NO EVENT SHALL ZETETIC LLC BE LIABLE FOR ANY
DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES
(INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES;
LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND
ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT
(INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS
SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

++++++++++++Boost++++++++++++++++++++++

<http://www.boost.org/LICENSE_1_0.txt>

Boost Software License - Version 1.0 - August 17th, 2003

Permission is hereby granted, free of charge, to any person or organization
obtaining a copy of the software and accompanying documentation covered by
this license (the “Software”) to use, reproduce, display, distribute,
execute, and transmit the Software, and to prepare derivative works of the
Software, and to permit third-parties to whom the Software is furnished to
do so, all subject to the following:

The copyright notices in the Software and this entire statement, including
the above license grant, this restriction and the following disclaimer,
must be included in all copies of the Software, in whole or in part, and
all derivative works of the Software, unless such copies or derivative

works are solely in the form of machine-executable object code generated by
a source language processor.

THE SOFTWARE IS PROVIDED “AS IS”, WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE AND NON-INFRINGEMENT. IN NO EVENT SHALL THE COPYRIGHT HOLDERS OR ANYONE DISTRIBUTING THE SOFTWARE BE LIABLE FOR ANY DAMAGES OR OTHER LIABILITY, WHETHER IN CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

++++++++++++++Openssl++++++++++++++++++++
<http://www.openssl.org/source/license.html>
/* ==
* Copyright (c) 1998-2011 The OpenSSL Project. All rights reserved.
*
* Redistribution and use in source and binary forms, with or without
* modification, are permitted provided that the following conditions
* are met:
*
* 1. Redistributions of source code must retain the above copyright
notice, this list of conditions and the following disclaimer.
*
* 2. Redistributions in binary form must reproduce the above copyright
notice, this list of conditions and the following disclaimer in
the documentation and/or other materials provided with the
distribution.
*
* 3. All advertising materials mentioning features or use of this
software must display the following acknowledgment:
* “This product includes software developed by the OpenSSL Project
for use in the OpenSSL Toolkit. (http://www.openssl.org/)"
*
* 4. The names “OpenSSL Toolkit” and “OpenSSL Project” must not be used to
endorse or promote products derived from this software without
prior written permission. For written permission, contact openssl-core@openssl.org.
*
* 5. Products derived from this software may not be called “OpenSSL”
nor may “OpenSSL” appear in their names without prior written
permission of the OpenSSL Project.
*
* 6. Redistributions of any form whatsoever must retain the following
acknowledgment:
“This product includes software developed by the OpenSSL Project

for use in the OpenSSL Toolkit (http://www.openssl.org/)"
*
* THIS SOFTWARE IS PROVIDED BY THE OpenSSL PROJECT ``AS IS'' AND ANY
* EXPRESSED OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR
* PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE OpenSSL PROJECT OR
* ITS CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL,
* SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT
* NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES;
* LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION)
* HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT,
* STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE)
* ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED
* OF THE POSSIBILITY OF SUCH DAMAGE.
* ==
*
* This product includes cryptographic software written by Eric Young
* (eay@cryptsoft.com). This product includes software written by Tim
* Hudson (tjh@cryptsoft.com).
*
*/

Original SSLeay License

/* Copyright (C) 1995-1998 Eric Young (eay@cryptsoft.com)
* All rights reserved.
*
* This package is an SSL implementation written
* by Eric Young (eay@cryptsoft.com).
* The implementation was written so as to conform with Netscape's SSL.
*
* This library is free for commercial and non-commercial use as long as
* the following conditions are adhered to. The following conditions
* apply to all code found in this distribution, be it the RC4, RSA,
* lhash, DES, etc., code; not just the SSL code. The SSL documentation
* included with this distribution is covered by the same copyright terms
* except that the holder is Tim Hudson (tjh@cryptsoft.com).
*
* Copyright remains Eric Young's, and as such any Copyright notices in
* the code are not to be removed.
* If this package is used in a product, Eric Young should be given attribution
* as the author of the parts of the library used.
* This can be in the form of a textual message at program startup or
* in documentation (online or textual) provided with the package.

*
* Redistribution and use in source and binary forms, with or without
* modification, are permitted provided that the following conditions
* are met:
* 1. Redistributions of source code must retain the copyright
notice, this list of conditions and the following disclaimer.
* 2. Redistributions in binary form must reproduce the above copyright
notice, this list of conditions and the following disclaimer in the
documentation and/or other materials provided with the distribution.
* 3. All advertising materials mentioning features or use of this software
must display the following acknowledgement:
“This product includes cryptographic software written by
Eric Young (eay@cryptsoft.com)”
The word 'cryptographic' can be left out if the routines from the library
being used are not cryptographic related :-).
* 4. If you include any Windows specific code (or a derivative thereof) from
the apps directory (application code) you must include an acknowledgement:
“This product includes software written by Tim Hudson (tjh@cryptsoft.com)”
*
* THIS SOFTWARE IS PROVIDED BY ERIC YOUNG ``AS IS'' AND
* ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
* ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE
* FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL
* DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS
* OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION)
* HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT
* LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY
* OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF
* SUCH DAMAGE.
*
* The licence and distribution terms for any publicly available version or
* derivative of this code cannot be changed. i.e. this code cannot simply be
* copied and put under another distribution licence
* [including the GNU Public Licence.]
*/
++++++++++++++Openssl++++++++++++++++++++

++++++++++++++GPLv2++++++++++++++++++++
GNU GENERAL PUBLIC LICENSE
Version 2, June 1991

Copyright (C) 1989, 1991 Free Software Foundation, Inc.
51 Franklin Street, Fifth Floor, Boston, MA 02110-1301, USA

Everyone is permitted to copy and distribute verbatim copies
of this license document, but changing it is not allowed.
Preamble

The licenses for most software are designed to take away your freedom to share and change it. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change free software--to make sure the software is free for all its users. This General Public License applies to most of the Free Software Foundation's software and to any other program whose authors commit to using it. (Some other Free Software Foundation software is covered by the GNU Lesser General Public License instead.) You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this service if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs; and that you know you can do these things.

To protect your rights, we need to make restrictions that forbid anyone to deny you these rights or to ask you to surrender the rights. These restrictions translate to certain responsibilities for you if you distribute copies of the software, or if you modify it.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must give the recipients all the rights that you have. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

We protect your rights with two steps: (1) copyright the software, and (2) offer you this license which gives you legal permission to copy, distribute and/or modify the software.

Also, for each author's protection and ours, we want to make certain that everyone understands that there is no warranty for this free software. If the software is modified by someone else and passed on, we want its recipients to know that what they have is not the original, so that any problems introduced by others will not reflect on the original authors' reputations.

Finally, any free program is threatened constantly by software patents. We wish to avoid the danger that redistributors of a free program will individually obtain patent licenses, in effect making the program proprietary. To prevent this, we have made it clear that any patent must be licensed for everyone's free use or not licensed at all.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS FOR COPYING, DISTRIBUTION AND MODIFICATION

0. This License applies to any program or other work which contains a notice placed by the copyright holder saying it may be distributed under the terms of this General Public License. The “Program”, below, refers to any such program or work, and a “work based on the Program” means either the Program or any derivative work under copyright law: that is to say, a work containing the Program or a portion of it, either verbatim or with modifications and/or translated into another language. (Hereinafter, translation is included without limitation in the term “modification”.) Each licensee is addressed as “you”.

Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running the Program is not restricted, and the output from the Program is covered only if its contents constitute a work based on the Program (independent of having been made by running the Program). Whether that is true depends on what the Program does.

1. You may copy and distribute verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and give any other recipients of the Program a copy of this License along with the Program.

You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Program or any portion of it, thus forming a work based on the Program, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions:

a) You must cause the modified files to carry prominent notices stating that you changed the files and the date of any change.
b) You must cause any work that you distribute or publish, that in whole or in part contains or is derived from the Program or any part thereof, to be licensed as a whole at no charge to all third parties under the terms of this License.
c) If the modified program normally reads commands interactively when run, you must cause it, when started running for such interactive use in the most ordinary way, to print or display an announcement including an appropriate copyright notice and a notice that there is no warranty (or else, saying that you provide a warranty) and that users may redistribute the program under these conditions, and telling the user how to view a copy of this License. (Exception: if the Program itself is interactive but does not normally print such an announcement, your work based on the Program is not required to print an announcement.)
These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Program, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Program, the distribution of the whole must be on the terms of this License, whose

permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Program.

In addition, mere aggregation of another work not based on the Program with the Program (or with a work based on the Program) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

3. You may copy and distribute the Program (or a work based on it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you also do one of the following:

a) Accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,
b) Accompany it with a written offer, valid for at least three years, to give any third party, for a charge no more than your cost of physically performing source distribution, a complete machine-readable copy of the corresponding source code, to be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,
c) Accompany it with the information you received as to the offer to distribute corresponding source code. (This alternative is allowed only for noncommercial distribution and only if you received the program in object code or executable form with such an offer, in accord with Subsection b above.)
The source code for a work means the preferred form of the work for making modifications to it. For an executable work, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the executable. However, as a special exception, the source code distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

If distribution of executable or object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place counts as distribution of the source code, even though third parties are not compelled to copy the source along with the object code.

4. You may not copy, modify, sublicense, or distribute the Program except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense or distribute the Program is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

5. You are not required to accept this License, since you have not signed it. However, nothing else grants you permission to modify or distribute the Program or its derivative works. These actions are prohibited by law if you do not accept this License. Therefore, by modifying or distributing the Program (or any work based on the Program), you indicate your acceptance of this License to do so, and all its terms and conditions for copying, distributing or modifying the Program or works based on it.

6. Each time you redistribute the Program (or any work based on the Program), the recipient automatically receives a license from the original licensor to copy, distribute or modify the Program subject to these terms and conditions. You may not impose any further restrictions on the recipients' exercise of the rights granted herein. You are not responsible for enforcing compliance by third parties to this License.

7. If, as a consequence of a court judgment or allegation of patent infringement or for any other reason (not limited to patent issues), conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot distribute so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not distribute the Program at all. For example, if a patent license would not permit royalty-free redistribution of the Program by all those who receive copies directly or indirectly through you, then the only way you could satisfy both it and this License would be to refrain entirely from distribution of the Program.

If any portion of this section is held invalid or unenforceable under any particular circumstance, the balance of the section is intended to apply and the section as a whole is intended to apply in other circumstances.

It is not the purpose of this section to induce you to infringe any patents or other property right claims or to contest validity of any such claims; this section has the sole purpose of protecting the integrity of the free software distribution system, which is implemented by public license practices. Many people have made generous contributions to the wide range of software distributed through that system in reliance on consistent application of that system; it is up to the author/donor to decide if he or she is willing to distribute software through any other system and a licensee cannot impose that choice.

This section is intended to make thoroughly clear what is believed to be a consequence of the rest of this License.

8. If the distribution and/or use of the Program is restricted in certain countries either by patents or by copyrighted interfaces, the original copyright holder who places the Program under this License may add an explicit geographical distribution limitation excluding those countries, so that distribution is permitted only in or among countries not thus excluded. In such case, this License incorporates the limitation as if written in the body of this License.

9. The Free Software Foundation may publish revised and/or new versions of the General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Program specifies a version number of this License which applies to it and "any later version", you have the option of following the terms and conditions either of that version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of this License, you may choose any version ever published by the Free Software Foundation.

10. If you wish to incorporate parts of the Program into other free programs whose distribution conditions are different, write to the author to ask for permission. For software which is copyrighted by the Free Software Foundation, write to the Free Software Foundation; we sometimes make exceptions for this. Our decision will be guided by the two goals of preserving the free status of all derivatives of our free software and of promoting the sharing and reuse of software generally.

NO WARRANTY

11. BECAUSE THE PROGRAM IS LICENSED FREE OF CHARGE, THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

12. IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MAY MODIFY AND/OR REDISTRIBUTE THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

NOTES

NOTES

IN CASE OF DIFFICULTY...

GE MDS products are designed for long life and trouble-free operation. However, this equipment, as with all electronic equipment, may have an occasional component failure. The following information will assist you in the event that servicing becomes necessary.

TECHNICAL ASSISTANCE

Technical assistance for GE MDS products is available from our Technical Support Department during business hours (8:30 A.M.–6:00 P.M. Eastern Time). When calling, please give the complete model number of the radio, along with a description of the trouble/symptom(s) that you are experiencing. In many cases, problems can be resolved over the telephone, without the need for returning the unit to the factory. Please use one of the following means for product assistance:

Phone: 585 241-5510	E-Mail: gemds.techsupport@ge.com
FAX: 585 242-8369	Web: www.gemds.com

FACTORY SERVICE

Component level repair of this equipment is not recommended in the field. Many components are installed using surface mount technology, which requires specialized training and equipment for proper servicing. For this reason, the equipment should be returned to the factory for any PC board repairs. The factory is best equipped to diagnose, repair and align your radio to its proper operating specifications.

If return of the equipment is necessary, you must obtain a Service Request Order (SRO) number. This number helps expedite the repair so that the equipment can be repaired and returned to you as quickly as possible. Please be sure to include the SRO number on the outside of the shipping box, and on any correspondence relating to the repair. No equipment will be accepted for repair without an SRO number.

SRO numbers are issued online at www.gedigitalenergy.com/Communications.htm. On the left side of the page, click “Login to my MDS” and once logged in, click “Service Request Order”. Your number will be issued immediately after the required information is entered. Please be sure to have the model number(s), serial number(s), detailed reason for return, “ship to” address, “bill to” address, and contact name, phone number, and fax number available when requesting an SRO number. A purchase order number or prepayment will be required for any units that are out of warranty, or for product conversion.

If you prefer, you may contact our Product Services department to obtain an SRO number:

Phone Number: 585-241-5540
Fax Number: 585-242-8400
E-mail Address: gemds.productservices@ge.com

The radio must be properly packed for return to the factory. The original shipping container and packaging materials should be used whenever possible. All factory returns should be addressed to:

GE MDS, LLC
Product Services Department
(SRO No. XXXX)
175 Science Parkway
Rochester, NY 14620 USA

When repairs have been completed, the equipment will be returned to you by the same shipping method used to send it to the factory. Please specify if you wish to make different shipping arrangements. To inquire about an in-process repair, you may contact our Product Services Group using the telephone, Fax, or E-mail information given above.

GE MDS, LLC
175 Science Parkway
Rochester, NY 14620
Telephone: +1 585 242-9600
FAX: +1 585 242-9620
www.gemds.com